

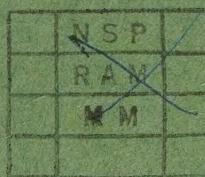
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ANNUAL REPORT

1960/61

COFFEE RESEARCH STATION, RUIRU
AND
COFFEE RESEARCH SERVICES
KENYA

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Published July
1961

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INTRODUCTION

In many respects the weather of 1960 in the coffee areas was remarkably similar to the previous year. After a normal dry season the Long Rains broke on time during the third week of March. In the East of Rift districts rainfall was heavy for some weeks, but early in May the Rains ended abruptly a month prematurely. Dry and abnormally warm conditions ensued for nearly six months until the Short Rains brought relief at the end of October. After one of the most prolonged dry periods recorded for many years the Rains were again unusually brief, lasting but three weeks and tailing away earlier than normal. Set against these conditions the salient feature of the year was an unusual proportion of early crop brought about by a similar but less severe weather pattern during 1959, which led to heavy flowering at the end of the year. Owing to the prolonged dry weather much of the early crop came to ripeness prematurely with size and quality adversely affected. The quality of the late crop was similarly affected by drought and, as in 1959, most of the new wood was sufficiently mature to bear flower in November. Undoubtedly the value of well-distributed rainfall can be most readily appreciated in such years when it is absent.

In the Rift Valley and West of the Rift conditions approached the normal pattern in most districts, although rainfall in April and May was lower than average.

Leaf Rust infections were generally less severe in all areas than in recent years due to the distinct dry seasons and relative absence of unseasonable rainfall. A similar situation prevailed with Coffee Berry Disease, although the level of infection was more variable. East of Rift the disease was at a relatively low level until infection built up during the Short Rains.

Inches per month	A	B	C	D	E	F	G	H
January	0.75	1.79	0.26	0.10	4.82	2.68	0.72	6.30
February	0.46	0.00	0.43	2.72	4.31	0.73	0.82	0.82
March	9.72	7.94	7.34	7.11	11.41	13.08	12.94	9.42
April	10.05	6.50	4.35	3.34	10.11	9.61	15.93	7.72
May	1.75	2.34	1.59	3.16	6.46	2.09	0.68	6.48
June	0.31	1.30	0.14	4.24	3.90	0.82	0.58	1.99
July	0.64	0.34	0.23	5.15	1.82	1.06	0.34	1.63
August	0.29	0.43	0.03	5.88	3.81	0.85	0.28	5.44
September	0.68	0.60	0.17	4.39	9.91	1.23	0.20	3.84
October	3.34	3.97	5.61	1.97	4.62	3.69	12.21	2.48
November	7.66	2.78	3.53	1.35	5.26	9.02	9.13	2.77
December	1.23	1.78	1.73	1.85	2.46	0.76	7.97	2.53
Total	36.88	29.77	25.41	41.26	68.89	45.62	61.80	51.42
No. of days Rainfall	103	104	69	165	214	127	129	148
Means and number of years	38.85 16	37.19 35	36.63 21	45.41 27	72.97 17	— —	— —	— —

- A = Coffee Research Station, Ruiru
- B = Scott Agricultural Laboratories, Kabete
- C = North Kitito Estate, Makuyu
- D = Kitale Experimental Station
- E = Kisii Coffee Research Substation
- F = Upper Kiambu Coffee Research Substation
- G = Mariene Coffee Research Substation
- H = Koru Coffee Research Substation

Leaf Miner continues to present the pest problem of greatest importance throughout the coffee-growing areas. Research on the problem was greatly augmented in the latter part of the year by the arrival of Dr. Bess, Senior Professor of Entomology at the University of Hawaii (on a nine months' Fulbright Scholarship), and by the arrival of Mr. P. E. Wheatley as second Entomologist, in November. Dr. Bess has focused most of his attention upon the bionomics of Leaf Miner with particular reference to the relation of chemical control to parasitism. Research on other major pests has continued, with some useful progress being achieved: study of the biology and/or checks upon estate control measures have led to a better measure of control of White Waxy Scale, Star Scale, Tip Borer and Yellow-headed Borer.

The salient points in the work of the Plant Pathologist were a co-operative project with Mr. Wallis on the use of low-volume sprays for the control of Leaf Rust, further work on the Stem-pitting conditions and initial investigations of nematode infestation of coffee nurseries.

In his research on coffee physiology, Dr. Wormer has continued his carbohydrate studies as the main project. Interesting progress was made in studying the water relations of the tree and on leaf fall. In collaboration with the Plant Pathologist the conditions known as "Hot and Cold" and "Crinkle Leaf" have received attention, their symptom patterns being defined and experiments initiated, designed to reveal the causes of each.

The research programme into soil fertility and plant nutrition problems was continued, but on a reduced scale after Mr. Robinson, the Agricultural Chemist, departed in March on transfer to the Coffee Research Station, Tanganyika.

Field investigations of necessity cover a wide field of cultural problems, on both the main station at Ruiru and on the seven substations listed in the Table of Rainfall data. During the year the range of field experiments was increased on all stations, particularly upon the four substations which have been established since 1957. In view of the dry conditions East of the Rift during the past two and a half years and the widespread Leaf Rust outbreaks which have affected coffee for the past five years, interest has centred on the irrigation experiment at the Coffee Research Station and studies of low-volume spraying for Leaf Rust control, with useful progress being made during the year on both projects. As in 1959 results from the Variety Trial programme were of special interest, an increasingly important factor being Leaf Rust resistance and its relevance to coffee development in the lower zones of the African areas.

The programme of coffee processing research was devoted to four main lines of work. Mr. Gough continued his experiments on methods of utilising ventilated bins and on the relation of the stage of cherry ripeness to quality. Mr. I. M. Johnson (Agricultural Engineer) at Nakuru made further progress with the problem of drying coffee in the initial stage after final washing. Mr. A. E. Wootton, E.A.I.R.O., continued his research into the causes of onion taint and is due to report the results of his investigations in March 1961.

Apart from the remaining vacancy for an Agricultural Chemist the staff position was satisfactory and relatively few changes occurred during the year. Mr. R. D. Scott and Mr. O. Andrade were appointed to posts created under the Expansion Programme. Mr. R. G. Pearce and Mrs. B. I. Coltman were appointed to temporary Coffee Board posts.

The demand for coffee seed rose to a level of 60 per cent more than in any previous year. Issues of seed totalled 11,738 lb. to plantations, 5,191 lb. to African Co-operative Societies and 128 lb. to other territories, making a total of 17,057 lb. of seed.

ADVISORY AND EXTENSION SERVICES

The level of advisory and extension services available in 1959 was maintained, although the demand for advice decreased noticeably. Uncertainty in the political future and prospects of falling prices for coffee were undoubtedly responsible for less interest in planting in new and unproven areas and a decline in replanting on established estates. Nevertheless, in addition to the normal channels by which advice is provided to growers from the Station and substations, the range of the advisory service is illustrated by the following:—

General Advisory Service. Mr. Cottington made 379 visits to plantations, with four tours of the Rift Valley and four tours in Nyeri district during the year. Mr. Toomey undertook the advisory work in Kericho, Elburgon and Ravine districts until his departure in May. Thereafter, in the absence of an advisory officer at Koru, Mr. Cottington became responsible for these areas also, making tours in Nyanza during the latter half of the year. Mr. Goodwin continued as advisory officer in Upper Kiambu, Limuru and Kabete districts until his departure on leave in December. Mr. de Vink continued his advisory duties in the Trans Nzoia, Uasin Gishu and Kaimosi districts. Mr. Hanger visited most of the African coffee-growing areas during the course of his advisory and liaison duties which have a country-wide coverage. Advice of a specialised nature was provided by the four specialist sections and the routine soil analysis and entomology services were continued.

District Tours. In addition to routine tours by Messrs. Cottington and Hanger a considerable number of district tours was undertaken by other officers: Messrs. Jones, Wheatley, Crowe, Wormer, Wallis, Firman and Harrison made a total of 25 tours to districts during the course of the year.

Field Days. The Annual Planters' Day was held at Jacaranda and Rukera Estates in July. The volume of work involved in preparation was formidable, but it was gratifying to learn that the event provided an enjoyable and instructive occasion for the 350 planters who attended. Field days were arranged for local planters at the Kitale substation in June and the Koru substation in January. Four officers also attended a field day organised by Mr. R. Johnston on his estate at Nyeri in June. Messrs. Wallis and Cottington attended the R.A.S.K. Farmers' Day held at Milmet Estate, Solai, in June.

Courses and Lectures. Courses were arranged for coffee officers, Assistant Agricultural Officers, Agricultural Instructors and for estate headmen at the Research Station. Messrs. Wallis and Crowe lectured on coffee to an Agricultural Officers' course held at Egerton College in August; Messrs. Wallis and Firman delivered the annual coffee lectures to students at the College in January. Discourses to district groups on various aspects of coffee growing were a regular feature as in past years.

Publications. The fourth separate edition of the Coffee Services' Annual Report was compiled and published on Planters' Day in July. For the latter the "Guide to the Coffee Research Station" was revised for the occasion and issued as a third edition. By the end of the year under review the Atlas of Coffee Pests, Diseases and Deficiencies had been printed and publication was imminent. All the colour transparencies required were assembled by May; after a considerable volume of preparatory work, in which Mr. Hanger rendered invaluable assistance in England, the final compilation was ready and submitted to the printers in London during August.

The "Better Coffee Farming" notes were continued as a monthly feature in *Kenya Coffee* as a means of passing information and advice to growers.

PUBLICATIONS

The following articles were published in *Kenya Coffee*, the Coffee Board of Kenya monthly bulletin:—

1960. VOL. XXV

April	"Cultivation of Vlei Soils," by J. B. D. Robinson. "A Coffee Seedling Disease," by I. D. Firman.
May	Annual Report for Coffee Team Services, by P. A. Jones.
June	"Resistant Varieties of Coffee in Relation to Physiologic Races of <i>Hemileia vastatrix</i> in Kenya," by B. F. Hanger and I. D. Firman. "The Control of Antestia with Pyrethrum," by T. J. Crowe and G. D. Glynne Jones.
July	"The Leaf Skeletonizer," by T. J. Crowe.
September	"Notes on Grasses for Mulching Coffee," by J. A. N. Wallis.
October	"Preliminary Report on the Control of Coffee Leaf Rust by Low-Volume Spraying," by J. A. N. Wallis and I. D. Firman.
November	"Field Investigations and the Coffee Grower in Kenya," by J. A. N. Wallis.
December	"Mites as Coffee Pests," by T. J. Crowe.

1961. VOL. XXVI

January	"Crinkle Leaf and Hot and Cold Symptoms in Coffee in Kenya," by T. M. Wormer and I. D. Firman.
March	"The Place of Herbicides in the Management of Kenya Coffee," by J. A. N. Wallis.

Articles published in other journals during the year were as follows:—

Wallis, J. A. N.	Control of Perennial Grasses in Coffee. <i>Proceedings of a Conference on the Control of Couch</i> . E.A.A.F.R.O., Muguga, March 1960.
Wallis, J. A. N.	Observations on the use of certain chemicals to mark Herbicides to be used on Grass. <i>Pesticides Abstracts and News Summary Section C</i> , 1960, Vol. 6, Nos. 2/3, p. 52.
Jones, P. A., Robinson, J. B. D., and Wallis, J. A. N.	Fertilizers, Manure and Mulch in Kenya Coffee Growing. <i>Empire Journal of Experimental Agriculture</i> , 1960, 28, 335.

FIELD INVESTIGATIONS CULTIVATION TRIAL

COFFEE RESEARCH STATION, RUIRU

Results from this experiment have shown quite consistently that thorough weed control is essential under local conditions. The 1960 crop was typical of many in showing that yields may be raised by over 50% if weeds are cultivated during the wet seasons.

TABLE I
1960 YIELDS
(Cwt. clean coffee per acre)

Weeding Treatments	Athi Plains Manure			Means for weeding treatments
	Nil	1 × 4 gall. tin per tree	Effect of Manure	
Wo Clean weeding	8.63	9.23	+0.60 NS.	8.93
W1 Weeds slashed	7.29	8.38	+1.09 NS.	7.83
W2 Tall weeds	5.40	6.13	+0.73 NS.	5.76
Means	7.11	7.91	+0.80	7.51

Data have been assembled from the ten crops 1951–1960, to analyse the effect of weed competition on the yield of Grade “A” coffee. During this period the gross yield response to clean weeding has been +55%, while in terms of Grade “A” coffee alone the increase has been +68%. Not only has weeding increased the yield but it has also raised the Grade “A” percentage by 3%.

TABLE II
1951–1960
(Cwt. clean coffee per acre)

	Yield	Effect	Grade ‘A’	
			Yield	%
Wo Clean weeding	9.53	+3.40***	3.67	38.51
W1 Weeds slashed	7.89	+1.76***	3.09	39.16
W2 Tall weeds	6.13	—	2.18	35.56
—C No manure	7.55	—	2.80	37.09
+C 1 × 4 gall. tin/tree annually . . .	8.15	+0.60**	3.16	38.77
Means	7.85		2.98	37.96

For the same ten-year period, it may be seen that one tin of Athi Plains manure per tree annually has raised the gross yield per acre by 0.60 cwt. clean coffee per annum (+8%) and the Grade “A” yield by 0.36 cwt. per annum (+13%).

ROTAVATOR TRIAL

COFFEE RESEARCH STATION, RUIRU

The results of this trial have been given in previous reports as gross yield per acre, but here are presented in terms of the mean annual yields of Grade "A" coffee for the seven seasons 1954-1960.

TABLE III

1954-1960

(Mean annual yields of Grade "A" coffee in cwt. per acre)

	<i>Fork</i>	<i>Rotavator</i>	<i>Rotavator effect</i>	<i>Means</i>
No mulch	2.10	2.19	+0.09	2.14
Mulch between alternate rows	2.53	3.02	+0.49**	2.77
<i>Effect of mulch</i>	+0.43**	+0.83***	—	+0.63***
Clean weeding	2.50	2.75	+2.75*	2.62
Tall weeds	2.13	2.46	+0.33*	2.29
<i>Effect of weeds</i>	-0.37**	-0.29*	—	-0.33
<i>Means</i>	2.31	2.60	—	2.46
<i>Coefficient of variation</i>	—	—	—	5.91%

Responses to Mulch in terms of Grade "A" yield

	<i>Fork</i>	<i>Rotavator</i>	<i>Key</i>
Clean weeding	+0.46*	+0.81***	* p = 0.05
Tall weeds	+0.39*	+0.85***	** p = 0.01
			*** p = 0.001

The implement used for weeding has not influenced the yield of Grade "A" coffee unless the coffee has been mulched in alternate rows. In this case, the "Rotavator" has been significantly more satisfactory than the hand fork. It is suggested that this effect may be the result of the better incorporation of old mulch residues into the upper soil layers.

IRRIGATION TRIAL

COFFEE RESEARCH STATION, RUIRU

Following the heavy crop recorded in 1959, when the mean yield for the trial was over 17 cwt. of clean coffee per acre, a light yield might have been expected in 1960. In fact, the mean yield for the trial was 21.29 cwt. per acre and in this crop substantial treatment responses were recorded for the first time since this trial started in 1956.

TABLE IV
1960
(Cwt. clean coffee per acre)

Time of Irrigation	Quantity of Sprinkler Irrigation Dec. 1959-Sept. 1960	Yield		Means
		No Nitrogen	46 lb. Nitrogen per acre	
(1) No irrigation	Nil	16.61	15.83	16.22
a. December only	7"	18.40	19.17	18.78
c. August only	9"	19.42	23.24	21.33
x As necessary	21"	27.07	27.88	27.48
Coefficient of variation . . .	—	10.18%		18.98%
Least significant differences		Within the table		Between means
p = 0.05		2.46		4.95
p = 0.01		3.32		6.81
p = 0.001		4.40		9.36

Only the most effective main treatments are shown in Table IV, which shows clearly the importance of the August irrigation. Moreover, nitrogen fertilizer, applied half in April and half in May, gave the greatest response when combined with the August irrigation. The most frequently irrigated coffee received water in December, February, March, May, July, August and September; with this treatment the trees yielded 11.26 cwt. per acre more than the unirrigated coffee.

The quantities of irrigation shown in the Table refer to sprinkler irrigation, whereof the trees received twice the quantity of water applied to basin-irrigated trees. No difference between these two methods was detectable in the 1960 crop yields nor in numerous determinations relating to the physiological state of the trees. Measurements of the soil moisture status close to the tree indicate that no differences could be expected to arise.

In November 1960, each head was measured to determine the vertical growth since November 1959. Over 3,000 heads were measured but no difference in growth could be detected between treatments. The mean vertical growth during the year was 19.85 cm. (approx. 8 inches) with a coefficient of variation of 11.28%. At this time there were marked visual differences between treatments differences which must be attributed to variations in secondary growth. Invariably the trees which had received nitrogen appeared more vigorous than those without nitrogen addition; trees irrigated in August had withstood the severe drought very well. See also Table XLIX.

MANURIAL, FERTILIZER AND MULCH TRIALS

MANURIAL TRIAL I

COFFEE RESEARCH STATION, RUIRU

In 1960 there was no yield response to the urea or sulphate of ammonia treatments. The plots receiving two 4-gallon tins of cattle manure per tree produced $2\frac{3}{4}$ cwt. clean coffee per acre more than the unmanured coffee, and over 2 cwt. of this increase was of Grade 'A' coffee. Cattle manure raised the Grade 'A' percentage by 6.31%.

TABLE V
1960 YIELDS
(cwt. clean coffee per acre)

<i>Treatments</i>	<i>Total yield</i>	<i>Grade 'A' cwt.</i>	<i>Grade 'A' %</i>
No manure	14.59	5.44	37.29
1 4-gallon tin per tree .	15.50	6.45	41.61
2 " " " " " .	17.34	7.56	43.60
<i>Mean</i>	15.81	6.48	40.99
<i>Least significant differences</i>			
p=0.05	1.06	0.76	—
p=0.01	1.45	1.04	—
p=0.001	1.99	1.44	—
<i>Coefficient of variation</i> .	6.66%	11.71%	—

The beneficial effect of cattle manure on bean size may be seen also in the mean yields for the four seasons 1957–1960. During this period the higher rate of manure application raised the mean annual yield by 1½ cwt. clean coffee per acre, and two-thirds of this increase was as Grade 'A' coffee.

TABLE VI
1957–1960
(Mean annual yields in cwt. clean coffee per acre)

<i>Treatments</i>	<i>Total yield</i>	<i>Grade 'A' cwt.</i>	<i>Grade 'A' %</i>
No fertilizer	10.74	4.43	41.25
46 lb. nitrogen per acre urea	11.12	4.47	40.20
46 lb. nitrogen per acre as ammonium sulphate .	11.89	4.69	39.44
No manure	10.73	4.08	38.02
1 4-gallon tin per tree .	10.80	4.41	40.83
2 " " " " " .	12.22	5.10	41.73
<i>Mean</i>	11.25	4.53	40.27
<i>Least significant differences</i>			
p=0.05	0.76	0.50	—
p=0.01	1.04	0.69	—
p=0.001	1.44	0.95	—
<i>Coefficient of variation</i> .	6.74%	11.09%	—

Urea has been compared with sulphate of ammonia for four seasons at the rate of 46 lb. of nitrogen per acre applied annually in the early part of the Long Rains. The coffee has been unmulched at all times and pruned on a multiple-stem system for this phase of the trial. There has been no significant yield response to urea in any season or in the mean yields for the four crops. Ammonium sulphate has raised the mean annual yields by 1.15 cwt. of clean coffee ($p = 0.01$), but has failed to raise significantly the yield of Grade 'A' coffee. The implication is that the yield response to this fertilizer has been as beans of less than Grade 'A' size. This result is in marked contrast to the responses to cattle manure in this trial and to mulch in other experiments, where most of the yield increases were as Grade 'A' coffee.

In this trial urea has failed to raise the yield of coffee but in another investigation, described on page 10, it is shown that, during the same four seasons, urea at the same rate as in this trial raised the

mean yield by 2.63 cwt. clean coffee per acre ($p = 0.05$). The trials differ mainly in that this trial is unmulched, whereas the other received regular mulch between alternate rows of trees.

MANURIAL TRIAL II

COFFEE RESEARCH STATION, RUIRU

The trial has been recorded for 11 seasons but in no year or group of years was there any response to the use of phosphatic fertilizers; nitrogen applications have usually led to enhanced yields, but in relation to the rate of application (92 lb. nitrogen per acre) the mean annual response has not been very great, although it represents at current coffee prices (£300 per ton) a return of about five times the cost of the fertilizer.

TABLE VII
Mean Annual Yields 1950-1960
(cwt. clean coffee per acre)

Treatments Nitrogen fertilizer	Cattle manure		
	Nil	1 × 4-gallon tin/tree	Effect of manure
Nil	7.00	7.68	+0.68
92 lb. nitrogen per acre .	8.86	8.66	-0.20
Effect of nitrogen . . .	+1.86	+0.98	—
Least significant differences			
$p=0.05$	—	—	0.51
$p=0.01$	—	—	0.76
$p=0.001$	—	—	1.17
Coefficient of variation .	—	—	3.79%

An interesting feature of this trial has been the negative interaction frequently observed between the cattle manure and nitrogen fertilizer treatments. The use of the fertilizer nullifies the response to manure which used alone has slightly raised the mean annual yield of coffee ($p = 0.05$).

TABLE VIII
Mean Annual Yields 1951-1960
(cwt. clean coffee per acre)

Treatments	Total crop	Grade 'A' cwt.	Grade 'A' %
Nil	7.77	2.48	31.92
92 lb. nitrogen per acre .	9.17	2.96	32.27
Mean	8.47	2.72	32.11
Effect of nitrogen . . .	+1.40	+0.48	—
Level of significance . .	—	$p=0.001$	—
Coefficient of variation .	—	5.20%	—

In this trial the nitrogen fertilizer treatment has raised significantly the mean annual yield of Grade 'A' coffee by just under $\frac{1}{2}$ cwt. of coffee per acre. This is in contrast to an adjacent trial in which 46 lb. of nitrogen per acre annually raised the total yield but not the yield of Grade 'A' coffee. The only difference between the trials is that this is pruned on a single-stem system, while the other has been on a multiple-stem system for a number of years.

MANURIAL TRIAL IV

COFFEE RESEARCH STATION, RUIRU

The trial was begun in 1954 to study the interaction of mulch and nitrogen fertilizer treatments; it has shown clearly that the fertilizer is more effective when applied to bare soil than when scattered over the mulch.

TABLE IX
Yield Summary 1954-1960
(Mean annual yields in cwt. clean coffee per acre)

1960	Total yield	Grade 'A'	
		Yield	%
M ₀ No mulch	15.30	5.97	39.02
M ₁ 6 ft. mulch between alter- nate rows	17.12	6.87	40.13
M ₂ 4½ ft. mulch in each row	16.11	6.32	39.23
M ₃ 6 ft. mulch between all rows	16.94	6.75	39.85
Mean	16.37	6.48	39.58
Coefficient of variation	7.83%	12.43%	—
Least significant differences			
between mulched p=0.05	1.11	0.70	—
and unmulched p=0.01	1.48	—	—
treatments p=0.001	1.96	—	—

1954-1960			
M ₀ No mulch	10.04	4.45	44.32
M ₁ 6 ft. mulch between alter- nate rows	11.14	5.23	46.95
M ₂ 4½ ft. mulch in each row	11.75	5.51	46.89
M ₃ 6 ft. mulch between all rows	11.31	5.14	45.45
N ₀ No nitrogen, unmulched	9.44	4.36	46.19
N ₁ 69 lb. nitrogen per acre, unmulched	10.11	4.41	43.62
N ₂ 138 lb. nitrogen per acre, unmulched	10.58	4.59	43.38
General mean	11.18	5.15	46.06
Coefficient of variation	8.25%	11.01%	—
Least significant differences			
p=0.05	0.79	0.49	—
p=0.01	1.06	0.65	—
p=0.001	1.40	0.86	—

Heavy yields were recorded in 1960 from all plots, but there was no significant response to nitrogen fertilizer treatments. The mulch applications between alternate or all coffee rows raised the yield of coffee by 1.64 and 1.82 cwt. clean coffee per acre respectively.

The mean annual yields for the seven seasons 1954-1960 show that all the mulch treatments raised the gross yield and Grade 'A' yield of the coffee, and that on unmulched soil the higher rate of fertilizer (138 lb. nitrogen/acre) raised the gross yield, but did not affect significantly the yield of Grade 'A' coffee.

TABLE X

1954-1960

The influence of fertilizer placement or the response to nitrogen of mulched coffee
(Mean annual responses in cwt. clean coffee per acre)

lb. nitrogen per acre	Fertilizer placement Yields		Mean	Fertilizer placement Responses		Difference
Nil	10.48		10.48	—		
	<i>To bare soil</i>	<i>Over the mulch</i>		<i>To bare soil</i>	<i>Over the mulch</i>	
69	12.11	11.02	11.57	+1.63***	+0.54	+1.09
138	11.74	11.47	11.61	+1.26**	+0.99*	+0.27
Means	11.93	11.25	—	—	—	—

Where the fertilizer applications have been confined to the bare soil between bands of mulch, important responses have been recorded to both rates of nitrogen dressing, but the lower rate has been ineffective when scattered over the mulch.

MANURIAL TRIAL V
COFFEE RESEARCH STATION, RUIRU

The outstanding feature of this trial during 1960 was the very substantial effect of mulching between alternate rows of coffee, which amounted to an overall increase of 4.39 cwt. clean coffee per acre over the unmulched yield of 7.61 cwt.

TABLE XI
1960 YIELDS
(cwt. clean coffee per acre)

<i>Magnesium fertilizer/acre as 'Calmag'</i>	<i>No mulch</i>	<i>Alternate inter-row mulch</i>	<i>Effect of mulch</i>
M ₀ Nil	8.04	11.01	+2.97*
M ₁ 25 lb. magnesium . .	6.95	12.01	+5.06**
M ₂ 50 lb. „	6.56	12.28	+5.72**
M ₃ 100 lb. „	8.90	12.71	+3.81*
<i>Nitrogen fertilizer/acre as A.S.N.</i>			
N ₀ Nil	9.87	12.74	+2.87*
N ₁ 46 lb. nitrogen . . .	6.24	11.79	+5.55***
N ₂ 92 lb. „	6.71	11.46	+4.75**
<i>Means</i>	7.61	12.00	+4.39***
<i>Overall mean</i>	9.80		
<i>Coefficient of variation</i> .	18.87%		
	<i>Least significant differences within the table</i>		
	<i>between magnesium treatments</i>	<i>between nitrogen treatments</i>	
*p=0.05	2.53	2.19	
**p=0.01	3.74	3.24	
***p=0.001	5.77	4.99	

Applications of "Calmag" at rates the equivalent of up to 100 lb. of magnesium per acre failed to have any clear effect on the yield of coffee and, in the absence of mulch, the crop was actually reduced by the applications of ammonium sulphate nitrate.

MANURIAL TRIAL VI

COFFEE RESEARCH STATION, RUIRU

The comparison of kieserite and magnesite has continued since 1957 but yields have only been recorded for the three seasons 1958-1960. The trial is situated on old single-stem coffee which has been heavily mulched for a number of years, but which formerly had been appreciably eroded.

TABLE XII

Yield Summary 1958-1960

(Mean annual yields in cwt. clean coffee per acre)

<i>Fertilizer lb. per acre</i>	<i>Magnesium lb. per acre</i>	<i>Kieserite</i>			<i>Means for Magnesite</i>
		<i>0</i>	<i>112</i>	<i>224</i>	
		<i>0</i>	<i>20</i>	<i>40</i>	
<i>Calcined magnesite</i>					
0	0	10.30	11.38	10.13	10.60
45	20	9.47	9.55	9.75	9.59
90	40	11.40	10.70	10.71	10.94
<i>Means for Kieserite</i>		10.39	10.54	10.20	10.38
<i>Coefficient of variation</i>	13.50%	<i>No significant difference</i>			
<i>Grade 'A' Coffee</i>		<i>Overall mean</i>			3.96
<i>Coefficient of variation</i>	15.12%	<i>No significant difference</i>			

An analysis of the gross yields or yields of Grade 'A' coffee has revealed no difference of statistical significance between the treatments. Thus there is so far no evidence that annual applications of magnesium to the ground at rates of up to 80 lb. of the element per acre will raise the yield of coffee.

MANURIAL TRIAL VII

COFFEE RESEARCH STATION, RUIRU

This trial was laid down in 1957 following some preliminary observations in 1956 of various urea solutions for foliar application to coffee. The object was to compare the relative efficiency of the ground application of urea with the same fertilizer sprayed on to the coffee leaves. The preparatory work had shown that urea solutions of more than 2.5 w/w concentration were liable to cause leaf scorch. However, at this concentration very considerable volumes of water would be required to convey a moderate fertilizer application to the coffee leaves. In this trial, high-volume sprays of up to 400 gallons per acre were compared with the application of urea solutions of up to 33% w/w concentration sprayed on to the coffee with a motorised Knapsack Mistblower at 20 gallons per acre. With the highest concentration of urea, some slight scorch was apparent where the leaf tips curled up, but it was concluded that these concentrations would probably be safe with a tractor-mounted sprayer which would give a spray deposit far more uniform than is possible with a manually-directed portable sprayer.

TABLE XIII

Yield Summary 1957-1960

(Mean annual yields in cwt. clean coffee per acre)

<i>lb. Urea per acre All treatments in April</i>	<i>lb. Nitrogen per acre</i>	<i>Nil</i>	<i>Method of application</i>			<i>Means for rate of Nitrogen</i>
			<i>Ground</i>	<i>Foliar High vol.</i>	<i>Spray Low vol.</i>	
0	0.0	a. 7.83	—	—	—	a. 7.83
25	11.5	—	—	a. 9.01	a. 8.81	b. 8.91
50	23.0	—	a. 8.97	a. 9.61	a. 9.57	c. 9.38
100	46.0	—	a. 10.46	a. 9.24	a. 9.46	c. 9.72
200	92.0	—	a. 10.04	—	—	a. 10.04
<i>Means for method of application</i>		a. 7.83	c. 9.82	c. 9.29	c. 9.28	9.30
<i>Coefficient of variation</i>						25.65%
<i>Least significant differences</i>		a. and a.	a. and b.	c. and c.	a. and c.	b. and c.
<i>p</i> = 0.05		2.05	1.77	1.18	1.67	1.32

MANURIAL TRIAL VIII

COFFEE RESEARCH STATION, RUIRU

This trial was laid down on the area of the former Manurial Trial III in April 1960 to study further the subject of the time of application of nitrogen fertilizers. In all treatments ammonium sulphate nitrate was applied once or twice in the Long Rains but the main contrasts were the application of fertilizer to the ground in the Short Rains or equivalent rates of nitrogen applied as foliar sprays of urea in the dry season between the rains.

TABLE XIV

YIELDS FOR 1960

(Cwt. clean coffee per acre)

<i>Treatment</i>	<i>Yield</i>	<i>Response</i>	<i>Level of Significance</i>
Control—No fertilizer	12.59	—	—
60 lb. Nitrogen per acre	14.67	+2.08	<i>p</i> = 0.05
80 " " " "	13.00	+0.41	N.S.
120 " " " "	14.82	+2.23	<i>p</i> = 0.05
160 " " " "	12.70	+0.11	N.S.
<i>Coefficient of variation</i>	—	—	9.97%

Brief results are given here as 1960 was the first crop recorded from this trial. However, it is interesting that some treatments led to increases in the yield of coffee. A total application rate of 60 lb. of nitrogen per acre gave a 2-cwt. increase in yield of coffee and higher rates of application did not give proportionately higher crops.

TABLE XV
YIELDS FOR 1960
(Cwt. clean coffee per acre)
Dry season foliar applications and Short Rains ground applications

<i>Long Rains Application</i>	<i>Dry Season 3 Foliar Sprays = 20 lb. Nitrogen</i>	<i>Short Rains 20 lb. Nitrogen Ground Application</i>
40 lb. Nitrogen per acre . . .	14.19	15.14
50 + 50 lb. Nitrogen per acre . . .	14.27	15.36
Control—No fertilizer		12.59
<i>Least significant difference</i> $p = 0.05$		2.36

The apparent indications are that an application of a modest rate of fertilizer to the ground in the Short Rains is superior to the same rate of nitrogen applied to the leaves in the dry weather. However, in 1960 all the crop had been picked before the first Short Rains applications had been made. This would imply that the dry-weather sprays impaired the response to Long Rains applications of fertilizers.

MANURIAL TRIAL IX COFFEE RESEARCH STATION, RUIRU

This trial was laid down in April 1960 to compare various nitrogen fertilizers in the presence and absence of mulch. In all cases 100 lb. nitrogen were applied in three equal doses; early and middle of the Long Rains, and early in the Short Rains. The 1960 crop was picked on seven occasions between the beginning of June and the middle of October, with the main crop harvested in the middle of July.

TABLE XVI
YIELDS FOR 1960
(Cwt. clean coffee per acre)

<i>Nitrogen per Acre/Annum</i>	<i>No Mulch</i>	<i>Alternate Inter-Row Mulch</i>	<i>Effect of Mulch</i>	<i>Overall Yields</i>	
Nil	9.73	12.36	+2.63*	11.04	* = p at 0.05
100 lb.	11.60	12.33	+0.73	11.96	
<i>Effect of Nitrogen</i> . . .	+1.87*	— 0.03	—	—	<i>Coefficient of variation</i>
Overall yields					
± Nitrogen	11.13	12.33	+1.20	11.73	20.12%
Yields Grade "A" . . .					
± Nitrogen	5.50	6.67	+1.17	6.09	21.18%
Percent Grade "A" . . .					
± Nitrogen	49.42%	54.10%	+4.68%	51.92%	—

It is remarkable that although the trial had only begun shortly before the picking season, there was a substantial response to mulch in the absence of any fertilizer. In no case did the response to any of the six fertilizers reach statistical significance, but there was an overall response to nitrogen in the absence of mulching. A more detailed analysis of the results is not advisable until further crops have been recorded.

MULCH AND SOIL REGENERATION TRIAL

COFFEE RESEARCH STATION, RUIRU

Four crops have been recorded since a magnesium treatment was introduced into the first replicate of this trial. During this period the + magnesium plots have received a total of 220 lb. of the element per acre, but this treatment has had no effect on the mean yield of coffee.

TABLE XVII

Yield Summary 1957-1960

The Interaction of Mulch with Magnesium Fertilizer
(Mean annual yield in cwt. clean coffee per acre)

Mulch Treatments	4-year total 220 lb. Magnesium/Acre		Effect of Magnesium
	Nil		
No mulch	9.32	9.95	+ 0.63 N.S.
Alternate inter-rows, pre-rains (March) . .	11.41	11.92	+ 0.51 N.S.
All inter-rows, pre-rains (March)	11.68	12.29	+ 0.61 N.S.
All inter-rows, post- rains (July)	11.25	10.75	- 0.50 N.S.
Mean	10.92	11.23	+ 0.31 N.S.
N.S. Not significant Coefficient of variation	—	—	8.70%

Similar responses to mulch have been recorded, whether or not the magnesium fertilizers have been applied. In 1960, the mulched coffee yielded twice as much as the unmulched trees, but there was no significant response to any of the nitrogen fertilizer treatments.

TABLE XVIII

Yield Summary 1960

(Cwt. clean coffee per acre)

Mulch Treatments	Nitrogen Fertilizer at 46 lb. Nitrogen/Acre				
	Nil	Urea	Sodium Nitrate	Ammonium Sulphate Nitrate	Means for Mulch Treatments
No mulch	5.64	7.22	6.94	7.32	6.78
Alternate inter-rows, pre-rains (March) . .	10.14	12.67	11.09	10.80	11.17
All rows, pre-rains (March)	14.91	13.32	11.32	14.82	13.59
All rows, post-rains (July)	12.47	14.83	12.10	12.71	13.03
Mean	10.79	12.01	10.36	11.41	11.14
Coefficient of variation .	—	—	—	—	16.84%
Least significant differences	Within the Table		Between marginal Means		
p = 0.05	2.72		1.36		
p = 0.01	3.67		1.83		
p = 0.001	4.88		2.44		

Sodium nitrate significantly depressed the yield of coffee which had been mulched between all rows before the Long Rains.

CHELATE TRIAL I

COFFEE RESEARCH STATION, RUIRU

This investigation started with the planting of coffee seedlings in April 1956 to determine the influence on coffee of plant nutrients supplied as chelates, as the industrial by-product iron lignin sulphonate or as a glass frit mixture which contains iron, manganese, zinc, boron, copper and molybdenum. Details of the initial treatments are given in the adjoining Table. All treatments, except cattle manure, were applied again in November 1957, but the magnesium chelate was replaced by an equivalent rate of magnesium as Epsom Salts. In November 1958, the following treatments were applied once more: Iron, Manganese and Zinc Chelates, Epsom Salts and the glass frit mixture.

The nine main treatments were split once into single-tree sub-plots for the cattle manure comparison. There were seven replications of the main treatments so that, in all, 126 trees were individually recorded.

TABLE XIX

Stem Diameter Measurements (cm.)—15 cm. above ground-level

<i>Date of Observation:</i>	<i>24.6.57</i>	<i>29.5.58</i>	<i>20.5.59</i>	<i>25.5.60</i>
Nil	1.88	3.54	4.71	5.49
Iron	1.63	3.13	4.13	5.05
Manganese	1.79	3.27	4.50	5.36
Zinc	1.91	3.50	4.70	5.68
Copper	1.98	3.70	4.91	5.83
Magnesium	1.79	3.43	4.57	5.44
Iron }	1.99	3.63	4.86	5.80
Manganese }				
Iron Lignin Sulphonate	1.84	3.39	4.52	5.64
Fritted glass trace elements	2.01	3.52	4.81	5.86
<i>Coefficient of variation</i>	23.30%	14.62%	12.59%	11.36%
—Cattle Manure	1.85	3.44	4.62	5.59
+Cattle Manure	1.88	3.48	4.64	5.55
<i>Coefficient of variation</i>	17.83%	13.51%	12.59%	10.77%
<i>General Mean</i>	1.87	3.46	4.63	5.57
<i>Percentage of 1957 diameter</i>	100	185	248	298

The main stem diameters were measured annually towards the end of the Long Rains at a point 15 cm. above ground-level. It has been shown that certain interactions have occurred between some chelates and cattle manure (C.R.S. Report 1957/58, p. 56), but none of the treatments has had a beneficial effect on the rate of stem diameter increase. These measurements are interesting in that they indicate the growth rate of coffee seedlings under prevailing conditions. Four years from planting the stem diameters were three times as great as they were one year from planting.

Individual tree yields were recorded for the first two crops from the trial but revealed that none of the treatments had raised the yield of coffee and although the variability was rather high there were clear indications that, in the absence of cattle manure, the magnesium depressed the crop and in the presence of cattle manure the iron chelate had similarly reduced the yield of coffee.

TABLE XX

1959-1960

(Mean annual yields in cwt. clean coffee per acre)

Chelates	Rate		Cattle Manure in the Planting Hole		
	per tree gm. or ml.	per acre Kg or L	Nil	1 × 4 gal. tin per tree	Treatment Mean
Nil	—	—	10.26	8.21	9.24
Iron	20 gm.	10.74 Kg.	7.85	7.09	7.47
Manganese	20 "	10.74 "	9.10	7.44	8.27
Zinc	20 "	10.74 "	9.38	10.13	9.95
Copper	20 "	10.74 "	10.83	10.05	10.44
Magnesium	30 "	16.11 "	7.11	8.54	7.82
Iron	40 "	21.48 "	10.35	9.99	10.17
Manganese	40 "	21.48 "			
Iron Lignin Sulphonate	50 ml.	26.85 L	9.13	9.03	9.08
Fritted glass trace elements	92 gm.	49.40 Kg.	7.62	10.52	9.07
Mean			9.07	9.00	9.04
Coefficient of variation			29.35%		35.67%
Least significant differences					
p=0.05			2.80		2.38
p=0.01			3.73		3.18

COPPER SPRAY TRIALS

MACHINE SPRAY TRIAL II

COFFEE RESEARCH STATION, RUIRU

This trial was designed to compare an airblast medium-volume sprayer with a low-volume or "mistblower" type of machine. Both machines were used to apply a copper fungicide which previous work had shown would prolong the life of coffee leaves by delaying their shedding. It had been shown that for the best effect the spray should be applied during the latter part of the Long Rains period; therefore, in this trial the dates of spraying were 7.5.1956, 21.5.1957, 16.6.1958 and 20.5.1959. Yields were not recorded in 1956 but were recorded for the four seasons 1957-1960. Details of treatment and the mean annual yields for the whole course of the trial are given in the following Table.

TABLE XXI

COPPER SPRAY TRIAL 1957-1960

(Mean annual yield in cwt. clean coffee per acre)

lb. 50% copper fungicide per 100 gallons	Sprayer	Gallons per acre	lb. fungicide per acre	Yields		
				Total	Response	
					Cwt.	%
Nil	—	—	—	8.93	—	—
6.8	Agro Airblast	60	4.08	10.94	+2.01	+22.50
6.8	Micron Meg	20	1.36	9.42	+0.49	+ 5.49
6.8	" "	10	0.68	10.25	+1.32	+14.78
13.6	" "	10	1.36	11.02	+2.09	+23.40
34.0	" "	10	3.40	11.56	+2.63	+29.45
Mean		—	—	10.35	—	—
Coefficient of variation %		—	—	18.16	—	—
Least significant differences			p=0.05	—	1.47	—
			p=0.01	—	2.07	—
			p=0.001	—	2.92	—

At ten or 60 gallons per acre all spray treatments resulted in significant yield responses, but when the "Micron Meg" was used at 20 gallons per acre the treatment failed to raise the yield of coffee. This may be attributed to the fact that the sprayer was designed to apply spray at rates of ten gallons or less per acre and is unsuitable for applying higher volumes.

At ten gallons per acre it is not possible to detect significant differences between the three fungicide concentrations, although there is a clear trend for the higher concentrations to result in higher yields.

After four years the trial has now been terminated and from it the following conclusions may be derived. For the reduction of premature seasonal leaf-fall (as distinct from Leaf Rust) ten gallons per acre applied with a "Micron Meg" can be as effective as six times this volume applied with an "Agro Airblast". At 20 gallons per acre the "Micron Meg" is ineffective at the fungicide concentration tested.

At ten gallons per acre there was no significant difference between the 0.68% and the 3.40% w/w fungicide concentration, but it is possible that if this volume is to be used fungicide concentration of 1% to 2% w/w should be used, i.e. 1 to 2 lb. of a 50% copper fungicide per ten gallons water per acre.

This trial has been conducted during seasons in which Leaf Rust has become increasingly severe. Consequently protective sprays of copper fungicide were applied at the rate of about 7 lb. of a 50% copper formulation in 70 gallons per acre to the whole trial, including the "control" plots, during February and September 1957, March and October 1958, January, March, October and December 1959, March and April 1960. It is clear that the yield responses shown in the Table must be attributable to some factor other than Leaf Rust control because the timing of the experimental treatments would not have provided useful protection against this disease.

COPPER SPRAY TRIAL

KITALE SUBSTATION

Details of the objectives, treatments and results have been given in previous Annual Reports.

In 1960 the coffee sprayed with a copper fungicide in the middle of June yielded over 2 cwt. clean coffee per acre more than the unsprayed trees.

TABLE XXII
KITALE COPPER SPRAY TRIAL 1960
(Yield in cwt. clean coffee per acre)

Time of application	Total yield	Response	
		Cwt.	%
Nil	5.62	—	—
Mid-May	6.65	+1.03	+18.33
Mid-June	7.82	+2.20	+39.15
Late August	6.31	+0.69	+12.28
Mean	6.60		
Coefficient of variation	11.36%		
Least significant differences			
p=0.05	—	1.18	
p=0.01	—	1.59	
p=0.001	—	2.12	

These results confirm that under local conditions valuable yield increases may be expected if the coffee is sprayed in May or June, but a spray in late August is likely to be ineffective.

COPPER SPRAY TRIAL

NORTH KITITO ESTATE, MAKUYU

Six crops have now been recorded from this trial and the mean yields of coffee for this period make it clear that in Makuyu the correct time for copper spraying is during the Long Rains and not early in the Short Rains as might have been inferred from observation of the climatic pattern and cropping cycle.

TABLE XXIII

Yield Summary 1955-1960

(Mean annual yields in cwt. clean coffee per acre)

<i>Time of spraying</i>	<i>1955-1960</i>	<i>Effect</i>
Nil	6.17	—
Early Long Rains April	8.40	+2.23
Late Long Rains June	7.88	+1.71
Early Short Rains November	7.05	+0.88
<i>Mean</i>	7.38	—
<i>Coefficient of variation</i>	8.12%	—
<i>Least significant differences</i>		
p=0.05	—	0.96
p=0.01	—	1.38
p=0.001	—	2.02

Earlier reports showed that the late Long Rains was a better time to spray than in early April, but now the position is reversed. It is suggested that this change is associated with the increased incidence of Leaf Rust and the fact that the early Long Rains treatment may afford some protection against the disease. There is no difference of statistical significance between the early and late Long Rains treatments, both of which have raised the mean annual yield by about 2 cwt. of clean coffee per acre.

MULCH AND COPPER SPRAY TRIAL

AGRICULTURAL INVESTIGATION CENTRE, EMBU

It is remarkable that in none of the three seasons this trial has been recorded has the response to mulch attained statistical significance. In the aggregate figures for the period the two-third ground cover of mulch appears to have raised the yield by 1.34 cwt. per annum, but this is still less than the value required for the 5% level of probability.

TABLE XXIV

1958-1960

(Mean annual yields in cwt. of clean coffee per acre)

No mulch	13.71	No copper spray	13.32
33% ground cover	13.93		
66% ground cover	15.05	May copper spray	15.13
100% ground cover	14.22		
<i>Effects of 66% mulch</i>	+1.34	<i>Effect of copper spray</i>	+1.81
<i>Mean</i>	14.23	<i>Coefficient of variation</i>	10.70%
<i>Least significant differences</i>			
p=0.05	1.57		1.11
p=0.01	—		1.50

In 1958, 1960 and the mean annual yields for the whole period the copper spray in May has led to an increase in annual yield of about 2 cwt. clean coffee per acre and is thus a highly economical operation.

PRUNING TRIALS

PRUNING TRIAL I

COFFEE RESEARCH STATION, RUIRU

The comparison of single- and multiple-stem pruning systems on mature coffee has continued for 15 seasons. The results shown in the Table confirm the view that, in the long run, there is no significant difference between the yields from single- or multiple-stem coffee.

TABLE XXV

1946-1960

(Mean annual yields in cwt. clean coffee per acre)

Pruning System	Total Coffee		Grade "A"
	1960	1946-1960	1951-1960
"Multiple stem", 3 heads . . .	13.10	8.00	3.50
"Single stem", capped once . . .	8.44	8.08	3.52
"Single stem", capped thrice . . .	6.54	7.60	3.32
"Single stem", 2 stems . . .	9.44	8.17	3.53
Mean	9.38	7.96	3.47
Coefficient of variation	16.30%	6.44%	9.39%
Least significant differences			
p = 0.05	1.88	0.63	0.49
p = 0.01	2.60	—	—
p = 0.001	3.59	—	—

Multiple-stem pruning is generally recommended for practical reasons, but not because yields can be expected to be higher than from single-stem coffee.

PRUNING TRIAL II

COFFEE RESEARCH STATION, RUIRU

The operation of this trial continues to present considerable difficulties because the very adverse weather conditions during 1959 and 1960 made it necessary to modify treatments in the light of experience. The main purpose of the trial remains to investigate methods of crop regulation. Four levels of primary reduction are combined factorially with four levels of secondary limitation. The treatments may be summarised as follows:

TABLE XXVI

<i>Single Stem, 5 ft. 6 in. tall</i>	<i>Multiple Stem</i>		
<i>Control of primaries:</i> L0 20 primaries L1 25 " L2 30 " L3 35 "	Cut up to 2 nodes above "break" Cup up to "break" Cut up to 2 nodes below "break" Cut up to 4 nodes below "break"	<i>Mean values Dec. 1959</i>	
		<i>cm.</i>	<i>Primaries</i>
		120	45
		134	50
		137	50
<i>Control of secondaries:</i> S0 4 ft. of bearing wood per primary S1 3 ft. of bearing wood per primary S2 2 ft. of bearing wood per primary S3 1 ft. of bearing wood per primary	Secondaries within 18" of stem removed at all times Maximum of four bearing secondaries All secondaries removed at pruning All secondaries removed, always		
<i>Extra treatment</i> L1 Sx 4 ft. bearing wood on each of 25 primaries, remaining secondaries de-cropped	Cut up to "break". Secondary growth de-cropped	127	49

TABLE XXVII

1959-1960 Yield Summary

(Mean annual yield in cwt. clean coffee per acre)

	<i>Single and Multiple Stem</i>				<i>Single Stem</i>	<i>Multiple Stem</i>	<i>Overall Means</i>
	<i>L0</i>	<i>L1</i>	<i>L2</i>	<i>L3</i>			
S0	8.67	7.59	8.31	9.41	6.19	10.85	8.52
S1	8.21	9.00	9.62	9.17	6.40	11.60	9.00
S2	7.72	7.66	8.36	9.26	5.82	10.68	8.25
S3	6.60	7.61	6.44	8.21	4.35	10.03	7.19
Single Stem	4.90	5.83	5.78	6.25	5.69	—	—
Multiple Stem	10.70	10.11	10.58	11.77	—	10.79	—
Overall Means	7.80	7.97	8.18	9.01	—	—	8.24
L1 Sx	—	—	—	—	7.64	8.92	8.28
<i>Least significant differences</i>	<i>Within the Table</i> <i>Between overall Means</i>				<i>Between single- and multiple-stem Means</i>		
p=0.05	1.28				0.64		
p=0.01	1.75				0.88		
p=0.001	2.40				1.20		
Coefficient of variation	14.68%				7.48%		

The mean annual yields for 1959 and 1960 show that the more the primaries the greater the crop as the L3 treatment has yielded more coffee on the single- and multiple-stem trees. The most productive secondary control treatment on the multiple-stem trees has been S1, in which up to four bearing secondaries were allowed per primary. For the single-stem trees the L1 Sx treatment yielded the greatest crop; the 100 feet of bearing wood on each tree being supported by the maximum amount of non-bearing secondaries.

Although multiple-stem pruning is generally described according to the length of each head, in effect number of primaries, the coffee tree has a considerable ability to compensate for loss of primaries by carrying additional crop on secondary wood. It appears more important to consider the correct policy of secondary control than to argue the merits of cutting up the main stems to particular distances from the top of each head.

PRUNING TRIAL

KITALE SUB-STATION

The first yields were recorded from this trial in 1960 when the multiple-stem trees yielded nearly 4 cwt. of clean coffee per acre more than the single-stem trees.

TABLE XXVIII

(1960 yields in cwt. clean coffee per acre)

	Time of Pruning		Means for method of pruning
	After Stripping	After Flowering	
Single stem 20 primaries .	7.02	5.87	6.44
„ „ 25 „ .	4.76	5.68	5.22
„ „ 35 „ .	6.91	5.53	6.22
			5.96
Multiple stem 2 × 4 ft. heads	10.10	9.49	9.80
„ „ 2 × 4½ „ „	9.37	9.92	9.64
			9.72
Means for time of pruning .	7.63	7.30	7.46
Least significant differences .	Within the Table		Between single and multiple stem
p=0.05	1.47		0.67
p=0.01	2.01		0.92
p=0.001	2.74		1.25
Coefficient of variation . .	—		11.45%

There is no clear-cut effect of the time of pruning on the coffee yield, although with the later pruning time the differences between the treatments diminished. There was no difference between the yields from multiple-stem heads with 4 ft. or 4½ ft. of bearing wood.

GENERAL COFFEE CULTURE TRIALS

COFFEE RESEARCH STATION, RUIRU

The variability of the coffee planted in 1956 is proving to be most disappointingly high although the seedlings used were of good genetic and physical uniformity. It appears that the two dry years of 1959 and 1960 have emphasised the tree-to-tree variability and have thus seriously impaired the accuracy of the trials on this coffee.

TABLE XXIX

(Mean annual yields in cwt. clean coffee per acre)

	1960	1959-1960
No mulch	2.63	4.83
Alternate inter-row mulch	5.53	7.02
Response to mulch	+2.90 +110.26%	+2.19 +45.34%
Least significant difference $p=0.001$	1.53	2.56

Of the four factors tested in this trial, only mulching has had a major influence on the yields, and in 1960 produced 110% increase in crop. Nitrogen fertilizer, copper spraying and weeding treatments all failed to produce detectable differences in yield.

It is planned to introduce an irrigation treatment into this trial following the 1961 crop season, and it is hoped that this will enable the interaction of the factors of this trial to be studied with more success.

KITALE SUB-STATION

On three of the trials on the Kitale sub-station, which are designed to compare various cultural practices, no results of statistical significance were recorded in 1960, although the yields were quite satisfactory and the variability was not exceptionally high.

TABLE XXX

1960

(Yields in cwt. clean coffee per acre)

<i>Trial</i>	<i>Mean yield</i>	<i>Coefficient of Variation</i>
1. Mulch and nitrogen fertilizer	7.01	28.01%
2. Mulch, nitrogen and magnesium fertilizer	9.21	12.82%
3. Weeding and green manure	5.72	22.56%

SABOTI ESTATE, MOUNT ELGON

The first of a series of trials on Mount Elgon was recorded in 1959 and 1960. It is situated on mature coffee under Grevillea shade and has as its primary object the study of cultural measures designed to improve the cropping level. The following factors are combined as a 2^3 factorial with four replications. On two replications the shade has been considerably reduced, while on two replications the Grevillea spacing remains at 40 ft. $\times$ 40 ft.

- Pruning early: as soon as the crop has been picked.
- late: shortly after the main flowering.
- Cultivation $\pm$ deep cultivation during the dry season.
- Spraying $\pm$ copper spray in May and September at 1-2 pints per tree of a suspension of 6.8 lb. of a 50% copper fungicide per 100 gallons water.

TABLE XXXI

SABOTI. TRIAL I. 1959-1960

(Yields in cwt. clean coffee per acre)

	1959				1960
Light shade	5.16				13.34
Heavy shade	2.10				11.46
Effect of extra shade	-3.06***				- 1.88*
Mean	3.63				12.40
	Early Pruning	Late Pruning	Effect of delay	Means for spraying	Means for spraying
No copper spray	4.69	2.63	-2.06***	3.66	10.77
Copper sprays in May and September	3.68	3.52	-0.16	3.60	14.03
Effect of spraying	-1.01	+0.89	—	-0.06	+ 3.26**
Means for pruning	4.19	3.07	-1.12**	3.63	12.40
*p = 0.05, **p = 0.01, ***p + 0.001 Coefficient of variation					28.94%
					20.08%

In 1959 the greatest single factor affecting the level of cropping was the shade intensity. The lightly shaded coffee produced twice as much as that under heavy shade. This effect was still significant in 1960 but not nearly so marked. There was a curious interaction between the effects of copper spraying and the time of pruning in the 1959 yields, but in 1960 the only significant effect was the substantial response to copper spraying twice a year. The 30% increase in yield represented an extra 3.26 cwt. clean coffee per acre. This indicates that routine copper sprays on Elgon are likely to be at least as successful as they have been found to be in other parts of the country.

VARIETY TRIALS IN CENTRAL PROVINCE

COFFEE RESEARCH STATION, RUIRU. THIKA DISTRICT

Variety Trial I

This variety trial, which was planted in 1950, continues to demonstrate the superiority of the Scott Laboratory (S.L.) selections over those made on Kitamayu Estate (KIT), but within these groups the ranking in terms of yield fluctuates considerably. The yield from S.L.28 was unusually low in 1960 (7.76 cwt.) but this is explained by its rather excessive cropping in 1959 (20.40 cwt.). It is interesting to record that the percentage of Grade "A" coffee from S.L.28 was greater than any other variety in this trial during 1960. S.L.14 has been one of the most reliably high-yielding varieties in this trial and in 1960 significantly outcropped all others. Of the KIT selections, number 107 has generally been the most productive and has produced a satisfactory bean size. KIT 37 has a high mean yield but is liable to serious biennial bearing.

TABLE XXXII

1960

(Yields in cwt. clean coffee per acre)

Variety	Total Crop	Grade "A"	
		Yield	Percent-age
S.L.14	15.06	7.91	52.52
S.L.30	12.92	7.45	57.66
S.L.19	12.22	6.54	53.52
S.L.17	11.48	6.37	55.49
S.L.1	10.76	6.25	58.09
KIT 107	8.93	5.24	58.68
S.L.28	7.76	4.66	60.05
KIT 145	7.75	4.17	53.81
KIT 27	7.98	4.08	51.13
KIT 13	8.74	3.96	45.31
KIT 64	7.27	3.56	48.97
KIT 106	6.90	3.32	48.12
KIT 109	6.78	3.22	47.49
KIT 251	7.08	3.15	44.49
KIT 85	6.20	3.05	49.19
KIT 37	4.22	1.64	38.86
Mean	8.88	4.66	52.48
Coefficient of variation	15.14%	16.24%	—
Least significant differences			
p=0.05	1.91	1.08	—
p=0.01	2.48	1.44	—

Variety Trial II

Seven crops have been recorded from this trial, which was planted in 1951, and with considerable consistency the selections S.L.34, N.218 and Dalle (mixed) have produced yields distinctly greater than most of the other varieties under study. Of these three, S.L.34 yielded by far the most in 1960 when it produced over a ton of clean coffee per acre while maintaining a good proportion of the crop in Grade "A". The improved performance of S.L.9 is of interest, although this selection has been a fairly satisfactory yielder for many seasons.

TABLE XXXIII

1954-1960

(Mean annual yields in cwt. clean coffee per acre)

Variety	1960			1954-1960
	Total Crop	Grade "A"		Total Crop
		Yield	Percentage	
S.L.9	18.21	10.41	57.17	10.00
S.L.34	20.70	9.80	47.34	11.68
Kenya Selected Series "L"	20.22	9.14	45.20	9.87
S.L.28	18.88	8.88	47.03	9.63
K.P.532	17.51	8.80	50.26	9.45
S.L.18	15.64	8.63	55.18	8.66
S.L.18	19.19	8.26	43.04	9.05
Kents	15.83	7.54	47.63	9.10
N.218	16.56	7.50	45.29	10.94
M.48	15.72	7.40	47.07	8.14
K.7	14.79	7.22	48.82	9.80
S.L.10	16.08	6.93	43.10	8.24
N.100	16.07	6.74	41.94	9.23
M.83	16.75	6.31	37.67	9.87
M.65	15.83	6.17	38.98	9.12
S.L.6	13.68	6.00	43.86	7.54
Mocha	16.36	5.82	35.57	9.27
M.6	16.91	5.76	34.06	9.99
S.L.2	15.91	5.75	36.14	8.43
Dalle (mixed)	14.99	4.88	32.56	10.34
Dilla and Alghe	12.42	2.75	22.14	7.81
Mean	16.58	7.18	43.31	9.34
Coefficient of variation	7.70%	11.64%	—	4.32%
Least significant differences				
p=0.05	1.76	1.15	—	0.56
p=0.01	2.34	1.53	—	0.74
p=0.001	3.05	1.99	—	0.96

In 1960, three of the selections known to be resistant to Leaf Rust, yielded significantly less than the overall mean; these were K.7, S.L.6 and Dilla and Alghe. In the mean yields for the seven crops, K.7 is shown to have produced 9.80 cwt. clean coffee, which is only inferior to S.L.34 and N.218.

KENTMERE ESTATE, UPPER KIAMBU

There are two trials, including a total of 25 varieties, in an attempt to discover a selection resistant to Coffee Berry Disease which is also suitable for high altitudes. Half of the second trial will be sprayed for protection against Coffee Berry Disease from early in 1961, but the results given here are from trees so far unprotected against the disease.

TABLE XXXIV

1958-1960

(Mean annual yields in cwt. clean coffee per acre)

Trial I			Trial II		
Variety	1960	1958-1960	Variety	1960	1958-1960
Blue Mountain K.7 .	7.31	5.52	S.L.28 . . .	5.78	7.16
" " P.13 .	7.56	5.34	S.L.34 . . .	5.37	6.78
" " L.3 .	7.71	5.18	Ke.20 . . .	10.91	6.76
" " I.11 .	7.58	5.15	Blue Mountain N.4	10.17	6.74
" " N.1 .	7.85	5.02	" " I.5 .	9.75	6.22
" " P.12 .	6.80	4.98	" " X.6 .	9.04	6.18
" " Q.6 .	7.40	4.95	Kents . . .	5.45	5.70
" " S.10 .	7.24	4.84	Blue Mountain U.4	8.50	5.62
" " P.8 .	7.30	4.63	Geisha 1 . . .	2.25	5.08
" " R.12 .	6.74	4.59			
" " W.12 .	7.15	4.45			
" " J.7 .	6.53	4.43			
" " S.5 .	6.75	4.40			
Kenya Selected .	5.40	4.11			
Blue Mountain V.13 .	5.98	3.97			
Geisha 10 . . .	1.05	2.38			
Mean	6.65	4.62		7.47	6.24
Coefficient of variation .	18.06%	—		16.49%	—
Least significant differences					
p=0.05 . . .	1.53	—		1.84	—
p=0.01 . . .	2.05	—		2.54	—
p=0.001 . . .	2.69	—		3.49	—

Trial I produced a substantial crop in 1960 for the first time, but suffered severely from over-bearing and drought during the latter part of the season. There were few differences of statistical significance between the selections, but of the Blue Mountain types K.7, L.3 and W.12 produced the highest percentage of Grade "A" coffee.

Trial II showed Blue Mountain selections outcropping S.L.28 and S.L.34 for the first time in 1960, so that in the mean yields for the three seasons there has been little to choose between the varieties. S.L.28 and S.L.34 have given far larger beans with over 40% Grade "A" in contrast to 10-20% Grade "A" from the Blue Mountain selections. Geisha 1 and Blue Mountain I.5 produced less than 10% Grade "A" coffee in 1960, but 25% of the Geisha 10 crop was Grade "A" size.

OTHER VARIETY TRIALS IN CENTRAL PROVINCE

Details of the 1960 crop from ten trials in the Central Province are summarised in the adjoining table. With the notable exception of three trials in the Meru District, the level of cropping was low elsewhere, and few differences can be shown to be statistically significant. S.L.18 at the Scott Laboratories and S.L.28 in the main Makuyu trial were exceptional and out-yielded other varieties in these trials.

In Meru also S.L.28 produced yields which were greater than other varieties in most trials. In the two low-level altitude trials, at Kanuni and Ngeru, the cropping level was different but the variety, Barbuk Forest, carried small crops at both sites.

TABLE XXXV
1960
(Annual yields in cwt. clean coffee per acre)

	Scott Laboratories Kabete	North Kiito Makuyu	North Kiito Makuyu	Investigation Centre, Embu	Meriga Mieru Meru	Kiriani, Meru	Kirindini, Meru	Kajianduthi, Meru	Kanuni, Meru	Ngeru, Meru
Altitude	5,700	4,900	4,900	4,900	5,500	5,100	4,200	4,600	4,100	4,000
Rainfall	35	35	35	45	55	60	90	55	75	65
Trees per plot	15	20	1	9	9	9	1	1	1	1
S.L.6	4.60	—	—	—	—	—	—	—	—	—
S.L.9	—	6.49	6.11	—	—	6.43	—	—	—	—
S.L.14	—	5.74	5.33	4.76	—	—	—	—	5.60	11.19
S.L.17	6.61	—	—	—	—	—	—	—	—	—
S.L.18	7.85	—	—	—	—	8.55	—	12.32	—	—
S.L.28	5.11	9.26	7.52	4.54	21.90	8.33	14.46	17.48	5.45	14.28
S.L.34	4.84	—	—	3.45	17.78	—	—	—	—	—
Kenya Selected	—	—	—	—	15.98	—	—	—	7.59	13.51
Series "A"	6.90	6.36	6.62	—	—	—	—	—	—	—
Series "L"	—	—	—	—	—	—	—	13.30	7.23	12.03
Mocha	—	—	—	—	—	5.94	—	8.63	—	—
Ke.20	6.58	—	—	—	—	—	—	—	—	—
Blue Mountain	4.51	—	—	—	—	—	8.14	—	—	—
K.7	4.47	4.65	11.67	—	—	—	—	—	7.23	21.98
Kents	—	—	12.81	3.14	17.33	—	—	—	—	—
Meru Kents	—	6.55	—	—	—	8.58	11.88	18.14	—	—
N.39	—	—	—	—	—	—	8.63	—	—	—
N.100	—	—	—	—	12.57	—	—	—	—	—
N.197	—	—	—	4.29	—	—	—	—	—	—
Columnaris	—	—	—	—	—	—	—	—	3.29	8.67
Barbuk	—	—	—	—	—	—	—	—	—	—
Forest	—	—	—	—	—	—	—	—	6.29	10.06
Dalle (mixed)	—	—	—	—	—	—	9.58	—	—	—
Mean	5.72	6.50	8.34	4.04	17.11	7.57	10.54	13.97	6.10	13.10
Coefficient of variation	21.12%	16.64%	83.10%	32.80%	26.28%	25.47%	45.03%	66.28%	44.35%	30.54%
Least significant differences										
p=0.05	1.41	1.43	—	1.82	6.17	2.65	6.51	—	2.95	4.37
p=0.01	1.88	1.95	—	—	—	—	—	—	—	—
p=0.001	2.48	2.64	—	—	—	—	—	—	—	—

VARIETY TRIALS IN COAST AND SOUTHERN PROVINCES

Seven crops have been recorded from the trial at Wundanyi, but no significant difference can be shown between any of the varieties. The level of cropping has been good and variability on the low side.

The trials in the Mukaa and Mbooni Locations of Machakos District fail to reveal significant differences between varieties.

TABLE XXXVI

(Mean annual yields in cwt. clean coffee per acre)

District	Taita	Machakos				
Site	Wundanyi	Mukaa Simeon Kaleli	Mukaa Joel Nzioka	Mukaa Thomas Mbuvi	Mbooni Solo Kiamba	Mbooni Elijah Masuni
Altitude (feet)	4,800	5,500	5,600	5,750	5,400	5,880
Rainfall (inches)	55	—	—	—	—	—
Trees per plot	6	1	1	1	1	1
Seasons	1954-1960	1960	1960	1960	1960	1960
S.L.6	11.78	—	—	—	—	—
S.L.9	—	—	—	9.75	—	13.42
S.L.14	13.31	12.30	11.99	7.51	10.31	—
S.L.17	—	—	8.79	—	—	9.75
S.L.28	12.82	6.79	9.27	6.71	6.59	10.86
S.L.34	13.49	7.83	10.87	7.19	—	—
Kenya Selected "A"	—	10.87	11.50	6.87	5.36	9.83
Series L	—	—	—	—	7.11	—
K.7	12.31	3.40	—	—	6.09	—
Kents	—	—	—	—	—	10.31
K.P.532	12.19	—	—	—	—	—
Mean	12.65	8.24	10.48	7.61	7.09	10.83
Coefficient of variation	15.08%	67.97%	35.66%	73.05%	55.84%	36.87%

VARIETY TRIALS IN RIFT VALLEY PROVINCE

AGRICULTURAL EXPERIMENT STATION, KITALE

Heavy yields were recorded in 1960 from the Blue Mountain selections and, in particular, Geisha 1 produced an exceptionally high crop for the District. The performance of S.L.28 and S.L.34 appears disappointing, although these selections have yielded at a higher rate than is general in the Trans Nzoia District. A serious attack of Coffee Berry Disease was reported in August 1960, when it was observed that Geisha 9 and Blue Mountain P.13 were particularly resistant while all the Scott Laboratory (S.L.) selections suffered severely. The Geisha selections show promise of yielding well and having considerable resistance to Leaf Rust as well as Coffee Berry Disease, but the bean size is particularly small. For example, the following percentages of Grade "A" coffee were determined for the 1959 crop from this trial:

S.L.28	47.9%	Grade "A"
S.L.34	40.4%	"
Kents	40.9%	"
Blue Mountain K.7	23.6%	"
Blue Mountain N.1	14.9%	"
Geisha 1	11.6%	"
Geisha 9	11.2%	"

It is evident that Geisha selections could be valuable for a breeding programme but could not be distributed to coffee growers in their present form.

TABLE XXXVII

YIELDS 1960

(Mean annual yields in cwt. clean coffee per acre)

Variety		Yield
Geisha 1	.	17.66
Blue Mountain	I.5	15.22
"	" W.12	14.80
"	" K.7	14.61
"	" P.12	13.76
"	" N.1	13.37
"	" Q.6	13.10
"	" P.13	13.08
"	" P.8	12.73
Kenya Selected	.	12.51
S.L.2	.	11.95
S.L.1	.	11.23
Geisha 9	.	9.29
Kents	.	8.96
S.L.28	.	8.25
S.L.34	.	6.28
Mean	.	12.30
Least significant differences		
p=0.05	.	2.35
p=0.01	.	3.12
Coefficient of variation	.	16.60%

VARIETY TRIALS IN NYANZA PROVINCE

At Chemoge, on Mount Elgon, four 12×12 Latin Square variety trials were planted in 1956 to investigate growing conditions at the high altitude of 6,800 ft. The same 12 varieties were represented in single-tree plots in each of the four squares. One Latin Square was planted with *Cordia abyssinica* for shade, and a second square was planted with *Schizolobium excelsum*. The third and fourth squares were unshaded. On these is superimposed a mulch and manure trial with 12 tree-plots formed by the rows of the Latin Squares. The first yields from these trials were recorded in 1959 and the results from the square with lowest variability are given in Table XXXVIII. The shade species, mulch and manure treatments all failed to affect significantly the yield of coffee. Nevertheless, there was little discrepancy between the four squares in the performance of the 12 varieties, of which the most productive were Ke.20, Kenya Selected and K.7.

TABLE XXXVIII

(Mean annual yields in cwt. clean coffee per acre)

District	Elgon Nyanza	North Nyanza	South Nyanza	
Altitude	6,800	5,000	6,200	5,660
Rainfall	65	70	80	65
Site	Chemoge III	Shikusu	Keumbu	Kisii
Trees per plot	1	9	1	9
Season	1959	1957-1960	1960	1960
S.L.2	—	8.08	3.10	—
S.L.14	—	9.01	12.48	13.15
S.L.28	—	7.41	8.04	11.08
S.L.34	2.69	8.78	10.82	—
Kenya Selected	6.90	—	9.67	10.72
Mocha	—	—	12.22	—
Ke.20	5.12	—	—	—
Blue Mountain	4.02	—	—	8.67
K.7	5.78	8.17*	—	—
Kents	3.31	6.98	8.35	9.19
Kapretwa Series "A" } Thorold's " " }	3.77	7.30	9.76	9.72
KIT 145	—	—	—	10.69
N.100	—	—	10.16	—
Padang	2.87	—	—	—
Dalle (Melville)	1.31	—	—	—
Dilla (Melville)	1.96	—	—	—
Dilla and Alghe	3.72	—	—	—
Geisha	1.87	—	—	—
Mean	3.61	7.93	9.40	10.46
Coefficient of variation .	41.79	21.74	44.93	19.98
Least significant differences .				
p=0.05	2.37	1.01	3.98	2.28
p=0.01	3.15	1.36	5.30	3.07
p=0.001	—	1.80	6.89	4.07

*1959-1960 only.

Two variety trials were planted at Shikusu in 1954, and from the second trial yields have been recorded since 1957.* This trial is a 7×7 Latin Square with nine-tree plots. One of the varieties, S.L.30, was quickly eliminated by severe attacks of Leaf Rust and was replaced by K.7, which came into bearing in 1959.

Each plot of nine trees was split to allow the comparison of three methods of secondary pruning.

*Ref. Annual Report Coffee Research Services 1958/59, page 27.

TABLE XXXIX

Mean annual yields 1957-1960

(Cwt. clean coffee per acre)

<i>Pruning Treatment</i>		<i>Yield</i>
R.	All secondary growth removed	6.71
J.	Secondaries removed for first crop of each primary	7.34
C.	Secondaries only removed from proximal 12 inches of each primary	8.09
<i>Mean</i>		7.38
<i>Coefficient of variation</i>		20.33%
<i>Least significant differences</i> $p=0.05$		0.60
$p=0.01$		0.80

The most severe pruning treatment has caused a depression in mean annual yield of 1.38 cwt. of clean coffee per acre, confirming that some secondaries must be permitted to sustain the cropping primaries. There was no interaction between pruning systems and varieties. S.L.14 has performed well in this trial, but Kents has been disappointing despite its partial resistance to Leaf Rust.

The 1960 yields trials at Kisii and Keumbu also show that S.L.14 has out-yielded Kents under widely varying conditions, despite the fact that Kisii is on the fringe of an area in which Leaf Rust can be particularly serious.

AGRICULTURAL CHEMISTRY

SODIUM NUTRITION STUDIES

A study of the effect of sodium upon the nutrition of the coffee tree has been continued. This project was initiated in 1959 when a detailed evaluation of fertilizer responses showed that sodium nitrate fertilizer had been significantly more efficient than ammonium sulphate or ammonium nitrate, in the absence of a Napier grass mulch (1). The association of sodium uptake with this effect is one of the possible causative factors which is being studied.

Leaf samples were collected at monthly intervals during 1960 from bearing primaries in plots receiving (46 lb.) nitrogen per acre per annum as sodium nitrate (N/S) and as ammonium sulphate nitrate (A.S.N) in the Mulch and Soil Regeneration Trial. Both unmulched (control) and mulched plots (all inter-row mulch applied in March) were also sampled. The samples included first mature leaf pairs (the same as those sampled in 1959) and second bearing node leaf pairs.

The overall mean leaf values are summarised in Tables XL and XLI for the first mature leaf samples and second bearing node leaf samples respectively.

TABLE XL

Mean leaf analysis values for Sodium, Potassium, Calcium and Magnesium for the period January–December 1960

(% element in leaf dry matter—first mature leaf samples)

		Control	Sodium Nitrate	Ammonium Sulphate Nitrate	Means (72)
No mulch	Na	0.047	0.056	0.047	0.050
	K	2.08	2.01	2.32	2.14
	Ca	0.95	0.93	0.92	0.93
	Mg	0.44	0.48	0.43	0.44
Napier grass mulch	Na	0.049	0.059	0.046	0.051
	K	2.67	2.45	2.57	2.56
	Ca	0.83	0.93	1.00	0.92
	Mg	0.41	0.39	0.40	0.40
Means (48)	Na	0.048	0.058	0.047	—
	K	2.38	2.23	2.45	—
	Ca	0.89	0.93	0.96	—
	Mg	0.43	0.44	0.42	—
L.S.D's	Na	2 means of (48)=0.006*, 0.009**			2 means of (72)=0.17***
	K				
	Ca	2 means of (48)=0.08*, 0.12**			
	Mg				
		N.S.			

TABLE XLI

Mean leaf values for Sodium, Potassium, Calcium and Magnesium for the period January–December 1960

(% element in leaf dry matter—second bearing node samples)

		Control	Sodium Nitrate	Ammonium Sulphate Nitrate	Means (72)
No mulch	Na	0.052	0.081	0.056	0.063
	K	1.70	1.62	1.98	1.77
	Ca	1.64	1.63	1.60	1.62
	Mg	0.48	0.51	0.46	0.48
Napier grass mulch	Na	0.054	0.072	0.055	0.060
	K	2.21	2.09	2.14	2.15
	Ca	1.18	1.31	1.41	1.30
	Mg	0.26	0.31	0.28	0.28
Means (48)	Na	0.053	0.077	0.056	—
	K	1.96	1.86	2.06	—
	Ca	1.41	1.47	1.51	—
	Mg	0.37	0.41	0.37	—
L.S.D's	Na	2 means of (48)=0.006**, 0.011***			
	K	2 means of (72)=0.32*			
	Ca	2 means of (72)=0.24*			
	Mg	2 means of (72)=0.13**			

Sodium nitrate fertilizer has resulted in a significant increase in uptake of sodium by the coffee tree, as shown in both first mature and second bearing node leaf samples. Higher sodium values have been found in the second bearing node leaf samples than in the first mature leaf samples. Potassium values in the first mature leaf samples have been decreased significantly by sodium nitrate. There has been an apparent increase of leaf magnesium following the use of sodium nitrate in the absence of a Napier grass mulch.

Napier grass mulch has increased significantly the mean leaf potassium values in both the first mature and second bearing node leaf samples. The leaf magnesium and calcium levels in the second bearing node leaf samples are markedly and significantly decreased by a Napier grass mulch. This is in agreement with previous findings (2), where it was noted that a Napier grass mulch significantly increases levels of potassium and decreases leaf magnesium to a point where magnesium deficiency symptoms appear in the mature leaves.

The influence of sodium nitrate fertilizer on some elements in the leaf (first mature leaf samples) was reported in the 1959/60 Annual Report.

Figure 1 shows the variation of leaf sodium, potassium and magnesium with sampling time, in presence or absence of mulch (second bearing node leaf samples).

Sodium nitrate has raised the leaf sodium values throughout the sampling period, without changing the shape of the curves.

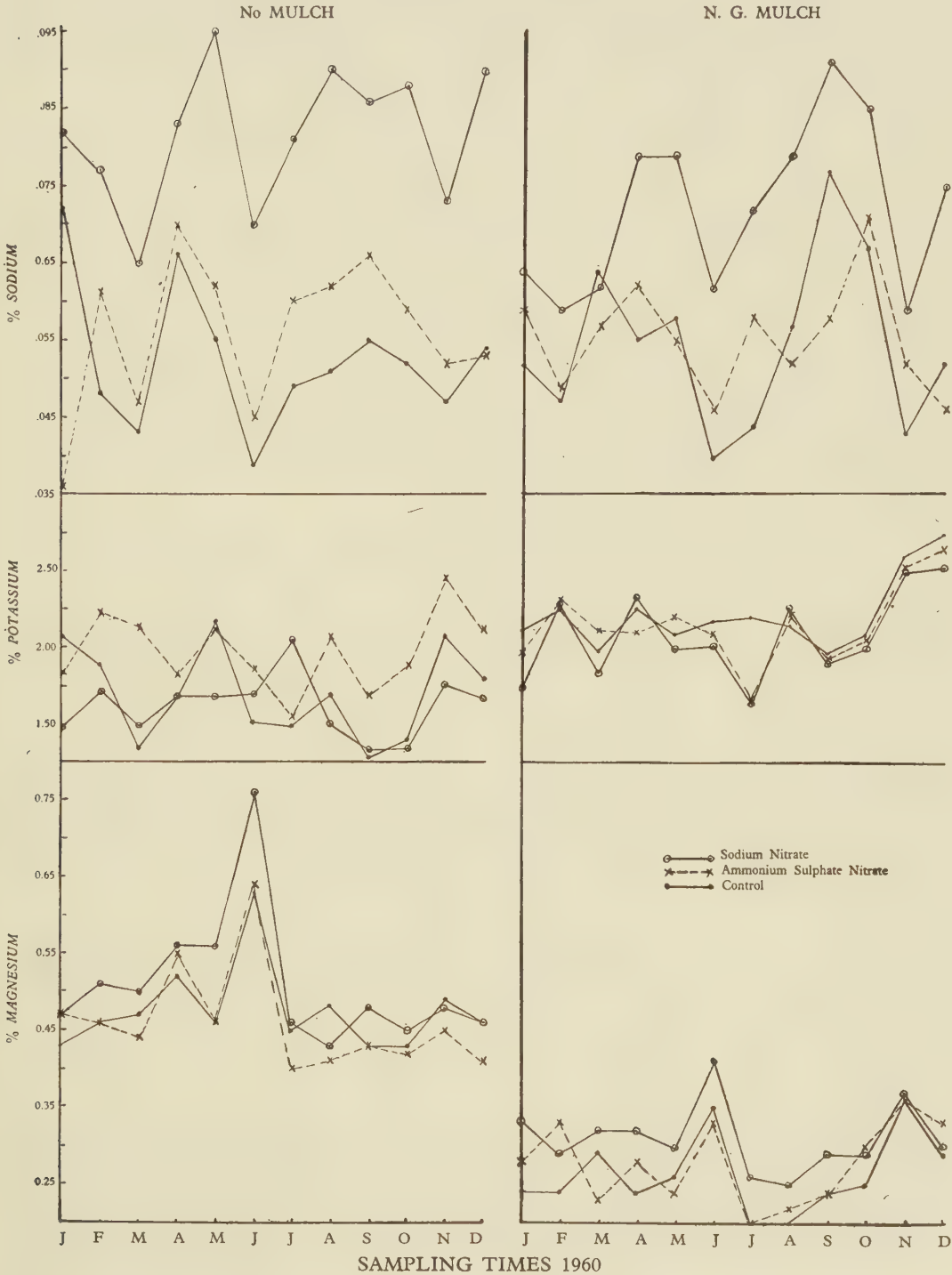
Potassium and sodium curves show less extreme changes in presence of Napier grass mulch.

Napier grass mulch has markedly raised the leaf potassium values. Over the sampling period, in the absence of mulch, the ammonium form of nitrogen fertilizer (A.S.N. in this case) appears to have favoured an increase in leaf potassium values and hence a decrease in leaf magnesium values. The same effects were apparent with urea (1959/1960 Annual Report, p. 64).

Leaf magnesium values were consistently low throughout the sampling time, in the presence of Napier grass mulch.

Figure 1

THE INFLUENCE OF SODIUM NITRATE FERTILIZER ON LEAF SODIUM, POTASSIUM AND MAGNESIUM (2nd bearing node leaf)



Micro-pot test

In addition to field work some micro-pot test work with sodium and potassium has been carried out. The aim of this work has been to study the relationship between the value of sodium and potassium in coffee tree nutrition. Hewitt culture working solutions (3) were used throughout these tests. Solutions Nos. 7 to 14 inclusive were taken as common factors in all the treatments. Both sodium nitrate and potassium nitrate, where not required, were replaced by magnesium nitrate.

The treatments consisted of three replications of six treatments (=18 pots) as follows:

- (a) -Na-K (control) : NaNO_3 and KNO_3 not added
1.789+0.625 gm. $\text{Mg}(\text{NO}_3)_2^*$
- (b) -Na + K : 2.02 gm. KNO_3
1.789 gm. $\text{Mg}(\text{NO}_3)_2$
- (c) $\frac{1}{2}\text{Na}$ - K : 1.70 gm. NaNO_3
0.895+0.625 gm. $\text{Mg}(\text{NO}_3)_2$
- (d) $\frac{1}{2}\text{Na}$ + K : 2.02 gm. KNO_3 and 1.70 gm. NaNO_3
0.895 gm. $\text{Mg}(\text{NO}_3)_2$
- (e) +Na - K : 3.40 gm. NaNO_3
0.625 gm. $\text{Mg}(\text{NO}_3)_2$
- (f) +Na + K : 2.02 gm. KNO_3 and 3.40 gm. NaNO_3

* 50 ml. of a working solution containing the weights of various nutrients, as given above, in ten litres were added weekly to 400 gm. soil for nine months.

The seedlings were removed from the pots when they were 12 months old and separated into leaves, stems and roots before washing and analysing.

TABLE XLII

Mean dry weights of leaves, stems and roots of coffee seedlings and % element in the dry matter

Leaves	-Na -K	-Na +K	$+\frac{1}{2}\text{Na}$ -K	$+\frac{1}{2}\text{Na}$ +K	+Na -K	+Na +K	L.S.D's
Weight (gm.)	2.67	2.89	3.29	3.36	3.33	3.89	0.63*
% Na	0.097	0.088	0.120	0.098	0.135	0.132	0.024*, 0.035*
% K	3.12	3.22	3.68	3.21	3.24	3.47	0.31*
% Ca	1.27	1.14	1.17	1.12	1.14	1.12	N.S.
% Mg	0.38	0.39	0.42	0.42	0.40	0.39	N.S.
% N	1.071	1.218	1.134	1.180	1.219	1.332	N.S.
Stems							
Weight (gm.)	2.23	2.57	2.60	2.62	2.98	3.32	N.S.
% Na	0.038	0.040	0.045	0.036	0.038	0.039	N.S.
% K	0.87	1.09	0.94	0.95	0.93	0.98	N.S.
% N	0.386	0.415	0.408	0.506	0.404	0.523	N.S.
Roots							
Weight (gm.)	2.51	2.40	2.33	2.60	2.68	2.73	N.S.
% Na	0.074	0.096	0.083	0.100	0.113	0.113	N.S.
% K	1.58	2.16	1.58	1.88	1.81	1.56	0.29*, 0.42**
% N	0.652	0.695	0.663	0.703	0.741	0.860	0.094*, 0.133**
Soil							
m.e. % Na	0.3	0.4	0.6	0.5	0.8	0.9	0.2*, 0.3**
m.e. % K	0.8	1.0	0.6	0.9	0.7	0.9	N.S.
m.e. % Ca	4.1	3.6	4.0	4.6	4.1	4.6	N.S.
m.e. % Mg	1.5	1.5	1.4	1.5	1.5	1.5	N.S.

Sodium and potassium (both as nitrate) alone or combined resulted in an increased dry weight of leaves over the control. It is apparent that sodium has been more effective than potassium in increasing the dry weight of the leaves. Similar trends, although insignificant, are apparent in the dry weights of stems and roots.

Sodium nitrate treatments have resulted in significant increases of sodium, both in the leaves and in the soil. Potassium nitrate, in the absence of sodium nitrate, significantly raised root potassium

values and raised slightly soil potassium levels. The increase of sodium content of plants following sodium fertilizers has been recorded by other workers (4, 5).

Nitrogen values have increased in leaves, stems and roots following sodium nitrate or potassium nitrate applications singly or combined. These values have reached significant levels only in the roots where the sodium nitrate effect is more pronounced than that of potassium nitrate.

NITROGEN FERTILIZER STUDIES

The Influence of Nitrogen Fertilizers on Growth, Leaf Nitrogen Content and Yield (Experiment No. II)

The nitrogen and mulch trial* (40 recorded trees) was modified in 1959 to compare the effects upon yields and leaf nitrogen values of various levels of ammonium sulphate nitrate fertilizer applied at different times, in the presence or absence of Napier grass mulch. (Mulch was applied around each tree.)

In previous years, leaf samples collected from this trial and analysed for total nitrogen content gave negligible differences in leaf nitrogen values between treatments.

In 1960 leaf samples were collected from bearing primaries at monthly intervals and analysed for total nitrogen content. The samples included first mature and second bearing node leaf pairs. The samples were taken from plots receiving the highest rate of ammonium sulphate nitrate (A.S.N.), the rate being 708 lb. per acre per annum (184 lb. nitrogen per acre).

The mean analysis values over the whole sampling period are given in Table XLIII.

*Coffee Research Station Annual Report 1958/59, page 34.

TABLE XLIII
(% of nitrogen in the leaf dry matter)

	<i>Control</i>	<i>+ Mulch</i>	<i>A.S.N.</i>	<i>A.S.N. + Mulch</i>
% N (first mature leaf)	2.198	2.157	2.244	2.232
% N (second bearing node)	1.546	1.559	1.658	1.611
L.S.D's (first mature leaf)	—	N.S.		
(second bearing node)	—	0.058*	0.107**	

The high rate of ammonium sulphate nitrate (A.S.N.) used has not raised significantly the nitrogen values in the first mature leaf. But the nitrogen values in the older leaves (second bearing node samples) are significantly higher in the nitrogen-treated plots than in the untreated plots.

The yield results for the 1960/1961 season are summarised in Table XLIV.

TABLE XLIV
MEAN YIELD RESULTS
(Cwt. clean coffee per acre per annum)

<i>Rate: lb. N/acre</i>	(1)	92	92	184	184	
Time of application and lb. N/acre	—	April 92	April 34½ May 34½ Nov. 23	April 92 May 92	Early April } 46 Late April } 46 May } 46 Nov. } 46	MEAN
(1)	14.28	12.48	16.68	10.69	15.31	13.89
Mulch	19.47	17.88	19.47	17.25	17.34	18.36
Mean	16.88	15.18	18.08	13.97	16.33	—

This trial consists of single-tree plots with four replications per treatment, plus or minus mulch. Results for some plots have been discarded as a result of a tree losing three or two of its heads under the weight of cherry: hence some treatment yield means are obtained from fewer plots than others. It is not possible therefore to draw definite conclusions, but mulch would appear to have increased yields. Some of the apparent differences between nitrogen treatments may be true effects.

The Influence of Nitrogen Fertilizer on Leaf Nitrogen in the Presence and Absence of Mulch

Leaf samples taken from the Mulch and Soil Regeneration Trial in 1960 were analysed for total nitrogen as already described in Sodium Nutrition Studies section in this report.

The mean analysis values over the whole sampling period are given in Table XLV.

TABLE XLV
(% of nitrogen in the leaf dry matter)

	<i>First mature leaf samples</i>		<i>Second bearing node leaf samples</i>	
	<i>No mulch</i>	<i>Napier grass mulch</i>	<i>No mulch</i>	<i>Napier grass mulch</i>
Control	1.950	2.053	1.455	1.539
Sodium nitrate	2.127	2.118	1.565	1.606
Ammonium sulphate nitrate	2.103	2.121	1.590	1.577
L.S.D.'s 2 means of (24) . .	0.072*	0.113*	0.104*	

In the absence of a nitrogen fertilizer Napier grass mulch would appear to have raised mean leaf nitrogen values. Both forms of nitrogen fertilizer have raised significantly the mean nitrogen values in both first mature and second bearing node leaf samples.

Considering the first mature leaf nitrogen values (the same as those sampled in 1959), it is evident that the overall changes in leaf nitrogen with time are highly significant (Fig. 2). The general trend of leaf nitrogen content changes with time has been closely similar to that reported in the 1959/1960 Annual Report. The increase in leaf nitrogen, which was recorded in November and December 1959, continued in January 1960. This level was relatively constant until May; thereafter it fell progressively as the topsoil dried out in June, to a minimum in October; it then increased substantially in November and December. The changes in the presence or absence of a Napier grass mulch are parallel. It is evident that the presence of a Napier grass mulch has raised leaf nitrogen contents at the minimum levels encountered and has also masked leaf nitrogen increases in response to nitrogen fertilizer applications. As stated in the 1959/1960 Annual Report (p. 60), Napier grass mulch lengthens the period of available topsoil moisture with a higher level of soil nitrate during the dry weather. The trend for the second bearing node samples is similar to that of first mature leaf samples, except that the nitrogen levels in the former fell in December.

MAGNESIUM SPRAY TRIAL

A short-term magnesium spray trial was carried out in 1960. The aim of the trial was to study the uptake (by the coffee tree) of magnesium from foliar sprays over a short period and to compare magnesium sulphate with magnesium nitrate. A more comprehensive trial of this nature is in progress, but no results are available yet.

The plot chosen for this trial had not previously received Epsom salt sprays. Each tree had three heads which were marked at random as A, B and C and treatments were assigned as follows:

A = Control, B = Magnesium sulphate, C = Magnesium nitrate.

For treatments B and C each head was sprayed with 200 millilitres of M/10 (where M = 246 grams of Epsom salt per litre or 256 grams of magnesium nitrate per litre).

Two replications of five trees each were used and two leaf pairs (third leaf pair) were sampled per head per sampling. Six samples were taken within 48 hours as shown in Figure 3.

The mean leaf magnesium levels did not show significant differences between treatments.

As shown in Figure 3, magnesium has been steadily taken up by the coffee leaves following a magnesium nitrate spray. Magnesium sulphate appears to have had no positive effect.

The superiority of magnesium nitrate over magnesium sulphate, as measured by magnesium uptake by leaves, has already been recorded (6).

Figure 2

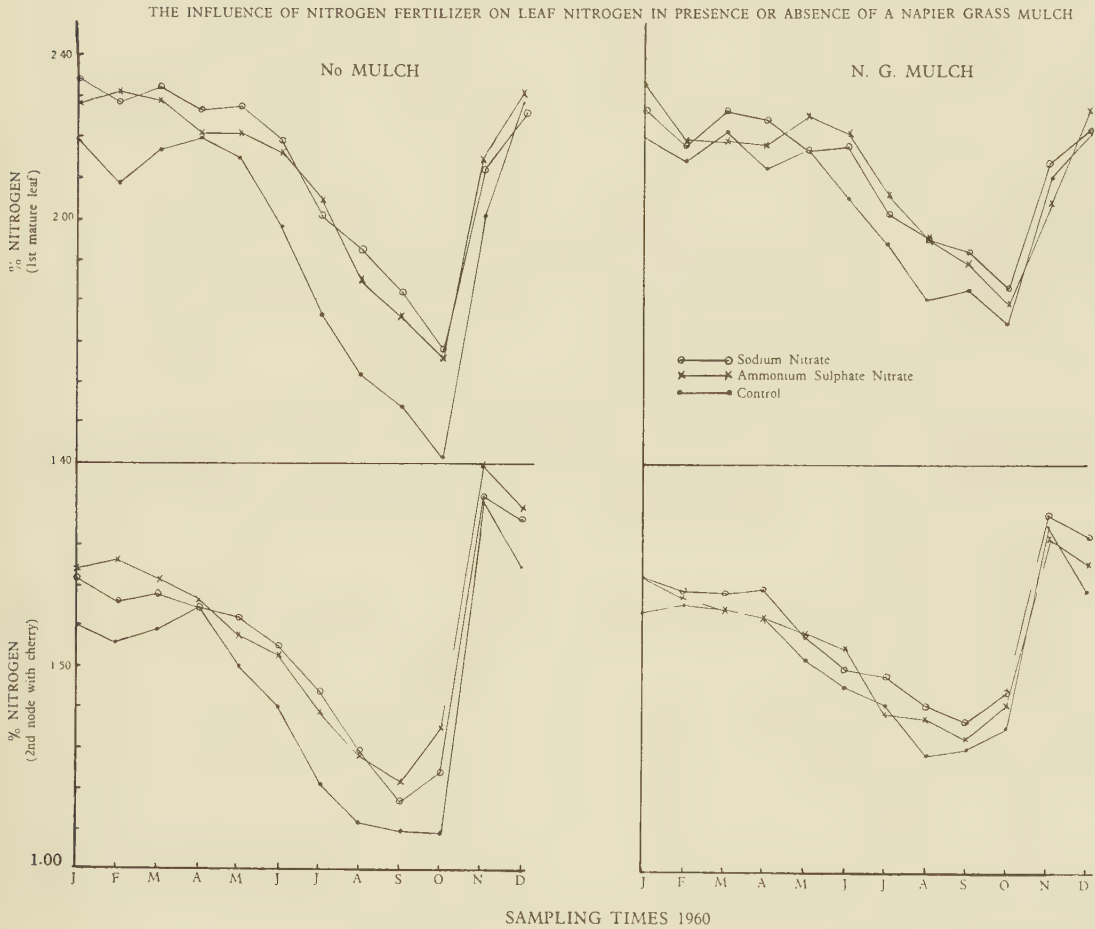
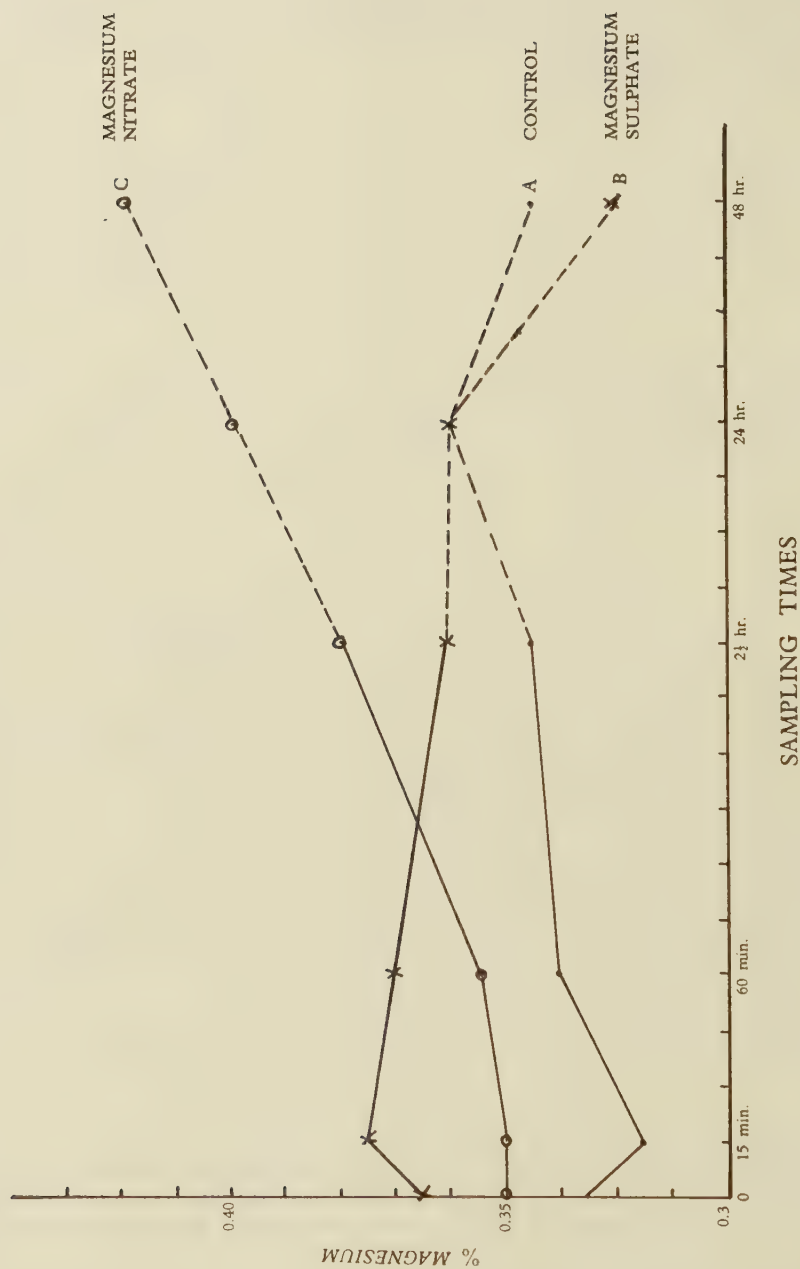


Figure 3
MAGNESIUM SPRAY TRIAL



COFFEE CHERRY ANALYSIS

Influence of a Napier Grass Mulch on Comparative Ripe Coffee Cherry Analysis

A short-term experiment was started in May 1959 to study the influence of a Napier grass mulch on comparative ripe coffee cherry analysis.

Samples of coffee cherries were taken at weekly intervals over a period of one month, from late May to late June 1959. Comparative samples were taken from mulched (all inter-row mulch in March) and unmulched plots in the Mulch and Soil Regeneration Trial.

The mean analysis values over the whole sampling period are summarised in Table XLVI.

TABLE XLVI

*Mean ripe cherry analysis values $\pm$ Napier grass mulch
(% of element in ripe cherry dry matter)*

<i>Treatment</i>	<i>N</i>	<i>P</i>	<i>K</i>	<i>Ca</i>	<i>Mg</i>
No mulch	1.317	0.1248	2.39	0.27	0.20
Napier grass mulch	1.264	0.1463	2.36	0.22	0.18
L.S.D's	0.050*	0.0119**	N.S.	0.03**	0.02**

Over the whole sampling period the Napier grass has significantly increased the mean levels of phosphorus and decreased the mean levels of nitrogen, calcium and magnesium. The mean potassium levels in the ripe cherry have not been increased by Napier grass mulch, in contrast to the effect Napier grass mulch has in raising the potassium levels in the leaves. None of the values for the elements determined showed marked variations with sampling time.

IRON CHELATE TRIAL

The fourth year's yield results were also the second crop from a new multiple-stem pruning cycle. More frequent leaf sampling from the Iron Chelate Trial was started in April 1959. The samples up to December 1959 have been analysed for both iron and manganese.

Table XLVII illustrates the yield results for four years, together with mean iron and manganese leaf contents over the sampling period.

TABLE XLVII

Mean yields and mean iron and manganese contents in leaf dry matter

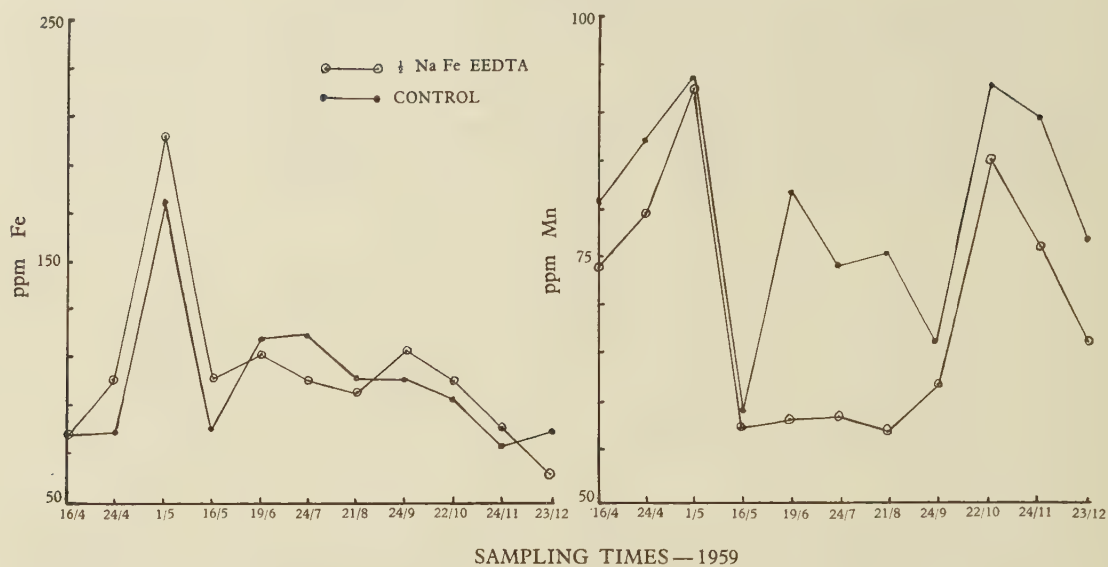
<i>Annual Treatment per tree</i>	<i>Yield (cwt. clean coffee per acre)</i>					<i>Leaf analysis</i>	
	<i>1957/1958</i>	<i>1958/1959</i>	<i>1959/1960</i>	<i>1960/1961</i>	<i>Mean (4 seasons)</i>	<i>ppm Fe</i>	<i>ppm Mn</i>
Control	15.0	2.5	4.3	19.2	13.2	100.0	80.1
$\frac{1}{4}$ lb. NaFeEDTA	15.9	3.9	1.6	12.7	10.0	95.7	71.6
$\frac{1}{2}$ lb. NaFeEDTA	19.5	2.8	2.8	16.4	12.4	103.3	70.2
L.S.D's: 2 means of (66)	—	—	—	—	—	N.S.	7.2*

Although trees in the trial bore heavy crops during the 1960/61 season no significant difference in yield was recorded between treatments. As shown in the Table the iron chelate treatments failed to raise the iron content in the leaves, but caused a significant drop in manganese content.

The overall changes in iron content with time (in presence or absence of iron chelate application) are parallel and significant, but the chelate has not significantly influenced this trend (Figure 4). The presence of iron chelate appears to have suppressed the uptake of manganese, particularly during the period when the topsoil was dry from June onwards.

Figure 4

IRON CHELATE TRIAL



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PLANT PHYSIOLOGY

Growth Recording

The growth recording at Scott Agricultural Laboratories (Nairobi) and at the Coffee Research Station was discontinued.

At Ruiru, the total rainfall was practically the same as in the previous year but was badly distributed. The early falls caused growth in the first half of March with very little difference between treatment affects. After March, the decline was very abrupt throughout April with a slight tendency to an increase in May, but by July the usual quiescent state, found during the cold weather, had set in and little further elongation took place until the first rains in October caused rapid growth just before the end of the experiment (see Figure 5).

As in previous years, the shaded trees topped the unshaded and the multiple-stem were ahead of the single-stem pruning. Stripping had very little effect. The trend to biennial bearing is confirmed by this year's yields as the single-stem trees had a heavier crop than the multiple-stem, and irrigation certainly exerted a beneficial effect (see Table XLVIII).

TABLE XLVIII

Growth recording: Coffee Research Station 1960

Yield corrected for cwt./acre of clean coffee

	Unshaded		Shaded		Means
	Unwatered	Watered	Unwatered	Watered	
Single	12.64	20.80	11.84	18.47	15.94
Multiple	2.61	6.87	3.04	4.48	4.25
Means	7.63	13.84	7.44	11.48	
	10.74		9.46		

Carbohydrate Studies

(a) The experiment designed to study the levels of starch and mineral elements in various parts of the tree is now in its second year. The anthrone-method used for determination of starch gave very unreliable results and was discarded. At present, "total reserve materials" (i.e. starch + sugars + hemi-celluloses) are determined in the form of glucose equivalent of the reducing substances. An arseno-molybdate colorimetric finish is used to Somogyi's sugar estimation following total reduction (Nelson: *J. Biol. Chem.* **153**, 1944, 375; Duff and Eastwood: *Nature* **165**, 1950, 848). As a result of the difficulties experienced with the anthrone-method, analysis of the samples collected so far is very incomplete.

(b) The method whereby the amount of starch in the wood is estimated after staining a section with iodine and assessing the intensity of the developing blue colour is now used to study various subjects, such as the interaction between primaries and secondaries and the effect of the growth of the berries on the food reserves in the wood. Most observations will be completed only after the 1960-1961 crop has been picked, but an example of the useful information which can be obtained by this method is given in Figure 6. The curves in this graph represent the amount of starch in comparable internodes of comparable primaries. The sharp drop in the amount of starch between January and February corresponds with the period of rapid growth of the berries resulting from a very heavy November flowering. Every curve is the average of five branches with the exception of the curve for April which is composed of the readings obtained from ten branches.

Figure 5

GROWTH RECORDS 1960 C.R.S.

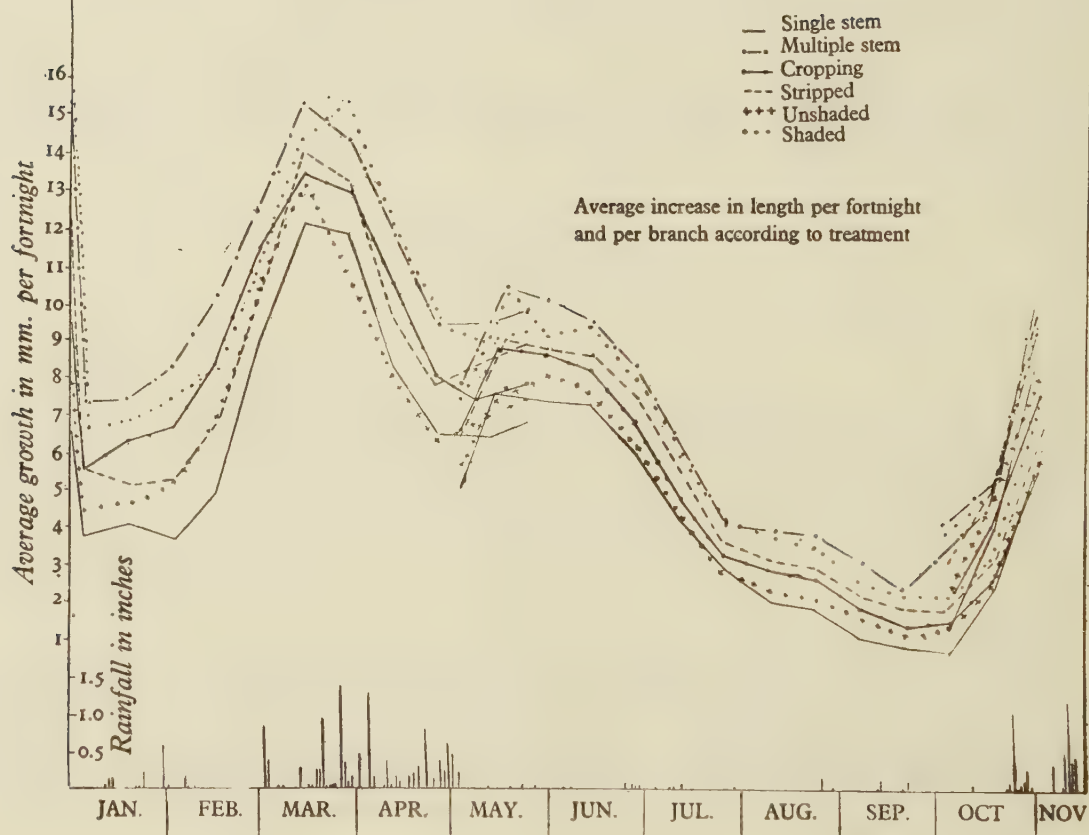
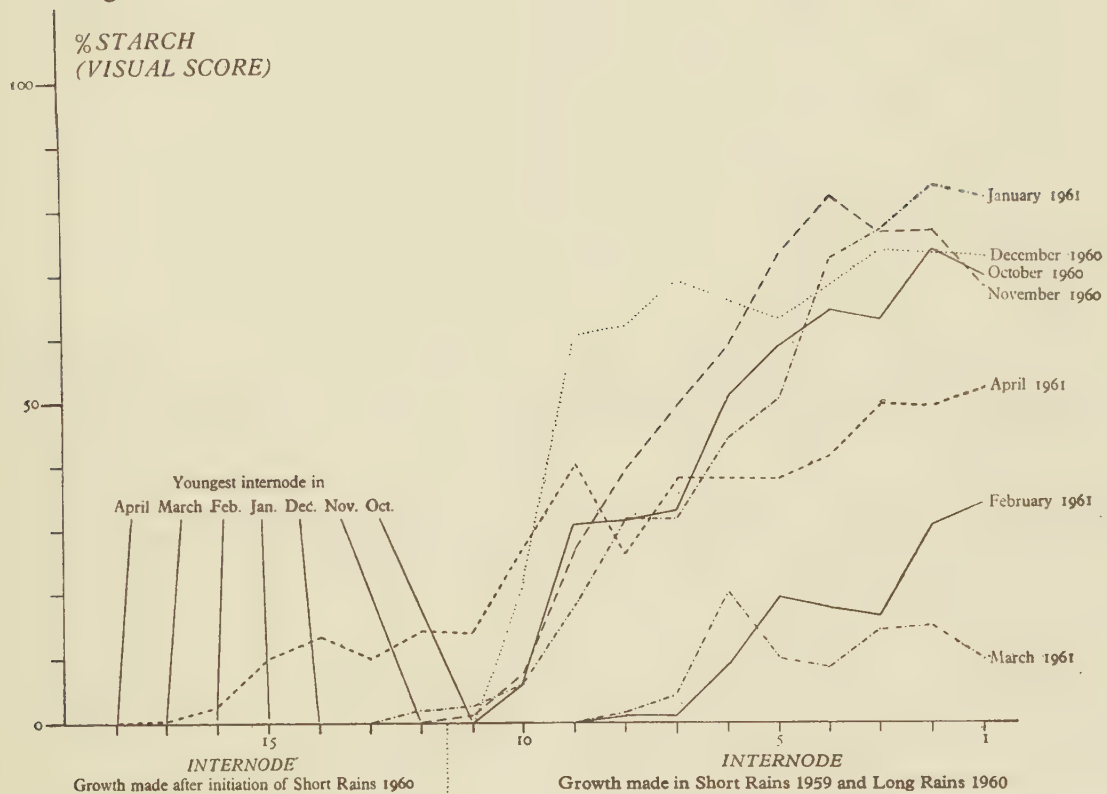


Figure 6



Water Relations

(a) Observations with the aid of Weatherley's method of measuring water deficit of leaves (*New Phytologist* **49**, 1950, 21-97; *ibid.* **50**, 1951, 36-51) confirmed the earlier impression that, apart from a small diurnal fluctuation, a serious water deficit develops only when the soil is near the permanent wilting point (see Figure 8a and Table XLIX). This means that the use of this method yields only very limited information on the behaviour of the plant over the greater part of the range of readily available water.

(b) Molisch's infiltration method of measuring stomatal aperture (*Zeitschr. Bot.* **4**, 1912, 106-122) offers greater possibilities. The following mixtures are being used:

Liquid No.	Vol. % of isopropanol	Vol. % of distilled water
1	100	0
2	95	5
3	90	10
4	85	15
5	80	20
6	75	25
7	70	30
8	65	35
9	60	40
10	55	45
11	50	50
12	45	55
13	40	60
14	35	65

The aperture of the stomata (which are found only on the lower surface of the leaf) is measured by finding that particular liquid which just penetrates, e.g. "aperture 5" means that a mixture of 80% alcohol and 20% water penetrates while a liquid with only 75% alcohol fails to do so. Obviously, "aperture 10" means a wider aperture than "aperture 6".

Pot experiments were carried out to study stomatal movement as a function of soil moisture. It soon became clear that other factors play a role, as could be foreseen, and no general picture can be given before the effect of these factors is better understood. Examples are given in Figures 7, 8 and 9. Stomatal aperture in Figure 7 is rather low. Evidently the stomata remain open early in the morning while the soil moisture content is slightly above the wilting point (=24.4%). Later in the day the stomata tend to close when the soil moisture is at a higher level and well above the permanent wilting point. Readings made at 5 p.m show a reverse tendency.

Figures 8 and 9 were obtained from a different soil, one with a permanent wilting point of approximately 30%. Figure 8 shows that the lack of soil moisture acted upon stomatal aperture when the humidity of the soil descended below 36% approximately. Readings made on the same plants on another day under different conditions produce a different curve; as shown in Figure 9, the stomata tend to close when the soil moisture is still well over 40%. It will be seen in the graphs that pure or nearly pure isopropanol penetrates even when there are visible signs of wilting.

The same method of measuring stomatal aperture is used in the Irrigation Trial. Sub-sub-plots are composed of ten trees and on six out of every ten trees three leaves are used for the observation. This system is based on a mathematical treatment of a great number of preliminary observations and has been adopted after consultation with the Statistician of the Agricultural Department.

The first results are summarised in Figure 10. It will be seen that stomatal aperture is very much reduced in the dry season, even in the frequently irrigated plots. The details of the observations show that stomatal aperture in coffee is closely dependent upon the influence of temperature, apart from the effect of soil moisture. This gives support to a suggestion already made by Heath and Orchard (*Nature* **180**, 1957, 180).

Table XLIX shows simultaneous observations of stomatal aperture and relative turgidity of the leaves, from the Irrigation Trial, but not on strictly comparable objects. From this Table it is evident that readings of stomatal aperture yield far more information than observations of the relative turgidity of the leaves.

TABLE XLIX

Stomatal Aperture and Relative Turgidity of the leaves in the Irrigation Trial

X = irrigation when the soil water deficit reaches 2 inches

a = irrigation end of Short Rains

I = no irrigation

Treatment	Stomatal Aperture					
	24.1.61 block I		25.1.61 block II		26.1.61 block III	
	+N	-N	+N	-N	+N	-N
X-ground . . .	4.57	3.70	5.77	5.23	6.27	5.27
a-ground . . .	3.47	3.23	5.22	4.03	4.63	3.90
I	2.73	2.10	2.80	1.67	2.97	1.87

Treatment	Relative Turgidity %					
	block I		block II		block III	
	+N	-N	+N	-N	+N	-N
X-overhead						
24.1.61 . . .	94.4	94.5	93.7	94.9	93.7	93.7
25.1.61 . . .	94.8	95.3	94.4	94.5	94.7	94.6
I						
24.1.61 . . .	93.4	92.0	94.7	94.7	93.8	93.4
25.1.61 . . .	94.1	93.6	94.2	94.4	94.8	94.1

Leaf Fall

Little work was done on this subject and it still remains to be proved that the method, whereby the action of chemicals is studied in the laboratory, will yield useful information for work in the field.

“Hot and Cold” and “Crinkle Leaf” Disease

Work on the development of the symptoms in relation to environmental conditions continues. The incidence at the Coffee Research Station was only light and little information was gained. Following Bock's observations (*Kenya Coffee* XXIV, 286, 1959) on the beneficial effect of spraying with Captan in controlling Crinkle Leaf, experiments were laid down in both East and West of Rift Areas.

Figure 7

STOMATAL APERTURE

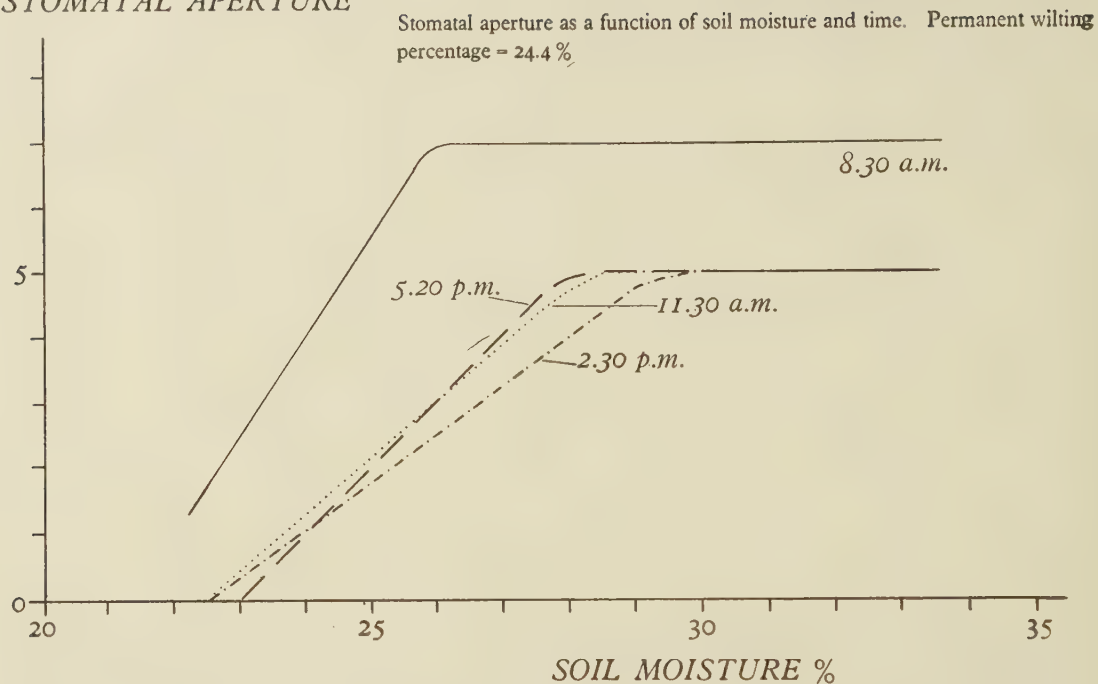


Figure 8 Relative turgidity of the leaves (a) and stomatal aperture (b) as a function of soil moisture under shade and in the sun. Permanent wilting percentage = approx. 30 %.

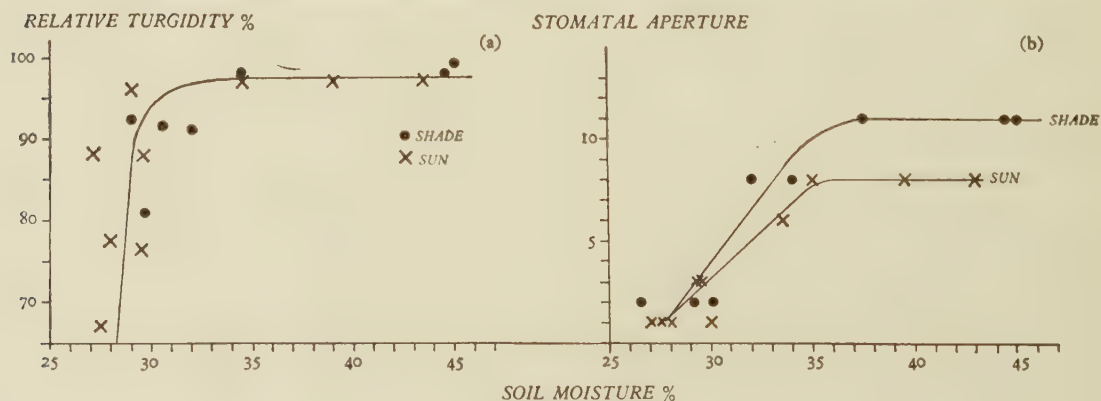
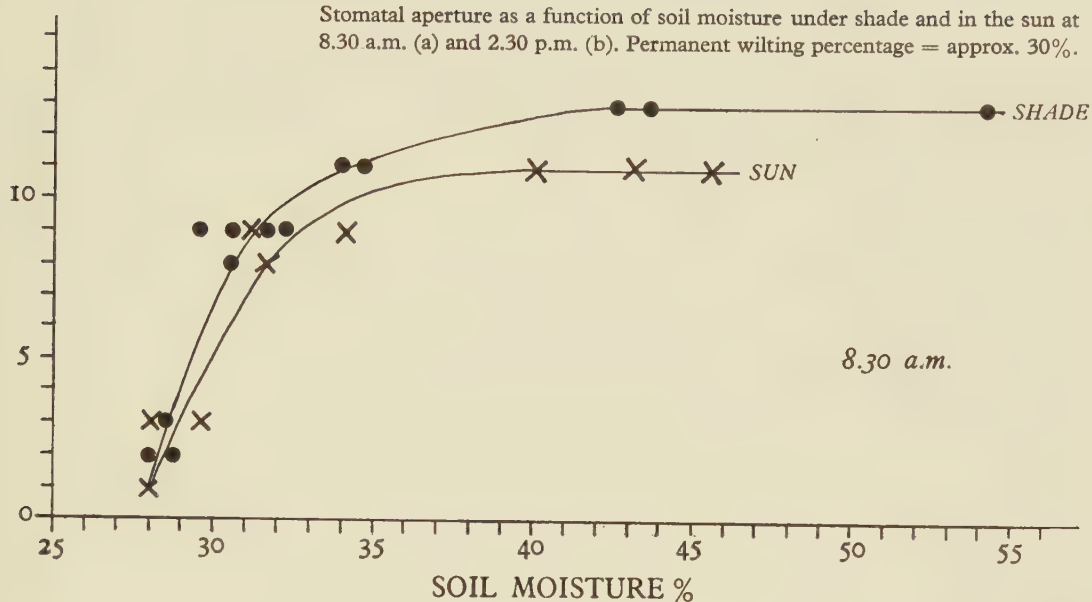


Figure 9

STOMATAL APERTURE

(a)

Stomatal aperture as a function of soil moisture under shade and in the sun at 8.30 a.m. (a) and 2.30 p.m. (b). Permanent wilting percentage = approx. 30%.



STOMATAL APERTURE

(b)

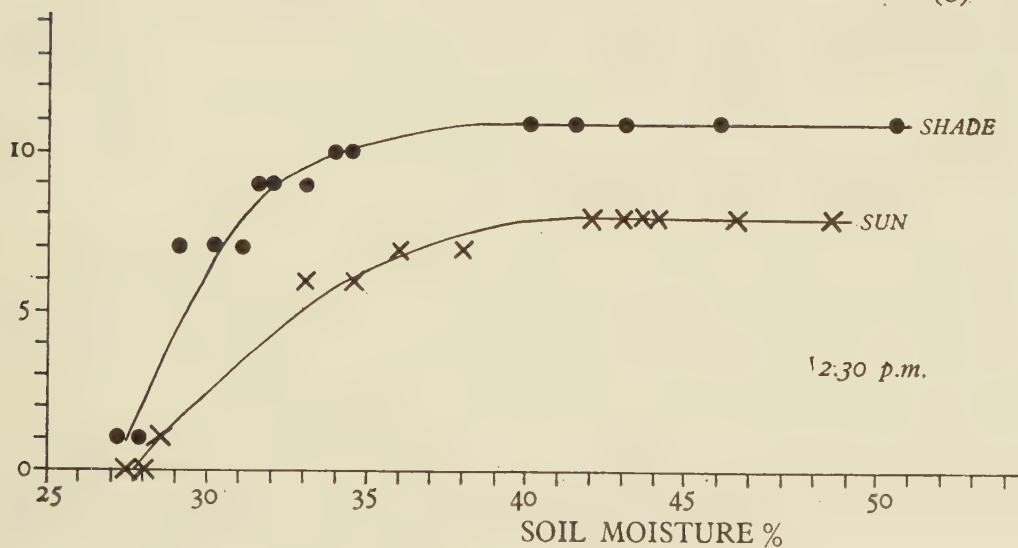
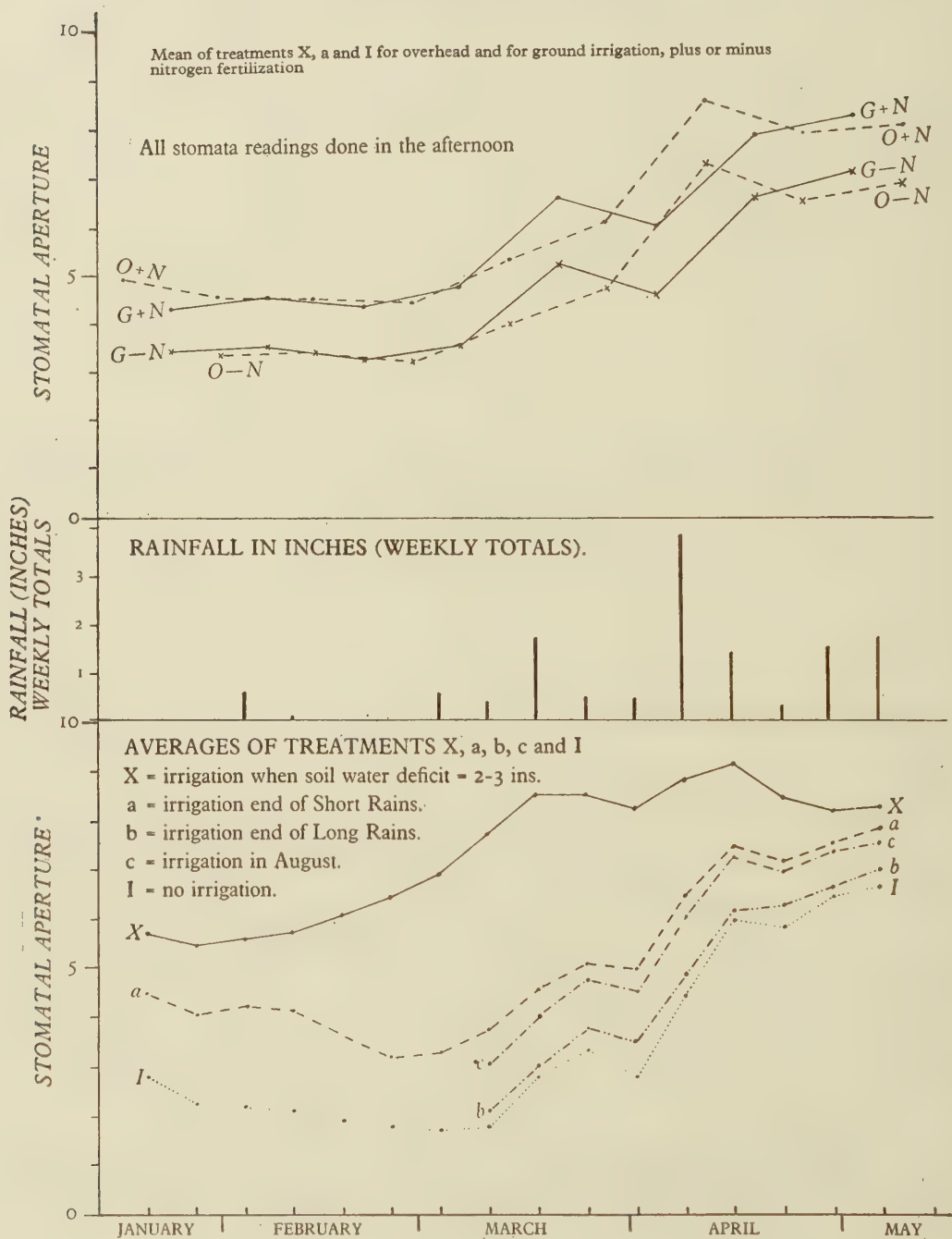


Figure 10

STOMATAL APERTURE IN THE IRRIGATION TRIAL 1961



PLANT PATHOLOGY

Leaf Rust

Hemileia vastatrix has been recorded on Robusta coffee for the first time in Kenya. In November 1960 specimens were received from Samia Location, Central Nyanza, and in December from Busia in Elgon Nyanza. This fungus (presumed Race IV) is present in Uganda from where it probably entered Kenya. Specimens received so far have not been sufficiently viable for race screening in the laboratory.

Fungicide Trials

The comparative trials referred to in the 1959/1960 Annual Report have been concluded. Throughout the duration of these trials Rust incidence has been low, so that marked differences between treatments could not be expected. It is not intended to carry out further comparative trials until experiments now in progress have shown the minimum copper dosages which can be expected to give good Rust control. Once this basic knowledge is established, different formulations can be critically compared on the basis of equal copper. Present indications are that copper for Rust control is usually applied at supra-optimal levels and that failures are due to inefficient application of sprays.

Fungicides I

The following fungicides were used:

Burgundy Mixture	..	..	..	..	..	..	..	Concentration 2%
Perenox (50% Cu as cuprous oxide)	..	..	..	..	..	..	..	10 lb./100 gals.
Oleocuvire (40% Cu suspension of yellow cuprous oxide in mineral oil and water emulsion)	..	..	..	..	..	..	..	6½ lb./100 gals.
Colloidal Copper (20% Cu)	..	..	..	..	..	..	..	2½ pt./100 gals.
Copper in Mineral Oil (40% Cu as copper oxydal)	..	..	..	..	..	..	..	2½ lb./100 gals.
Tricarbamix (iron, zinc and manganese carbamates)	..	..	..	..	..	..	..	5 lb./100 gals.
Copper oxychloride (50% Cu)	..	..	..	..	..	..	..	10 lb./100 gals.

All sprays were applied by hand with a Warley Eclipse sprayer at the rate of one pint per tree. Times of application are indicated on the appropriate graphs. Figures 11, 12 and 13 show the results graphically. Figure 11 includes the rainfall data during the experiment.

All treatments gave significant control of Rust during 1959 when the Rust level was relatively low, but in early 1960, when Rust reached a rather higher level, there was a considerable difference in efficiency. Only Burgundy and Perenox gave really consistent control. Yield results for the years 1959 and 1960 are summarised in the following table.

FUNGICIDES I

Yield Summary 1959/60

Cwt. clean coffee per acre per annum using an assumed cherry:
clean coffee ratio of 6:1

Control	..	..	..	..	2.91	Perenox	..	..	..	..	4.17
Copper in Mineral Oil	..	..	..	..	3.14	Oleocuvire	..	..	..	..	4.29
Tricarbamix	..	..	..	..	3.30	Colloidal Copper	..	..	..	..	4.38
Burgundy	..	..	..	..	3.85	Oxychloride	..	..	..	..	4.55
Least significant differences:					p = 0.05	0.95					
					p = 0.01	1.32					
					p = 0.001	1.84					

Since there was no means of determining the effect of controlling seasonal leaf-fall (due to the May spray), it is difficult to assess what portion of the total yield increase is attributable to Leaf Rust control. Nevertheless, five annual sprays (including the May) resulted in yield increases ranging from approximately 1 to 1½ cwt. per acre with five of the fungicides used.

Figure 11

FUNGICIDES I

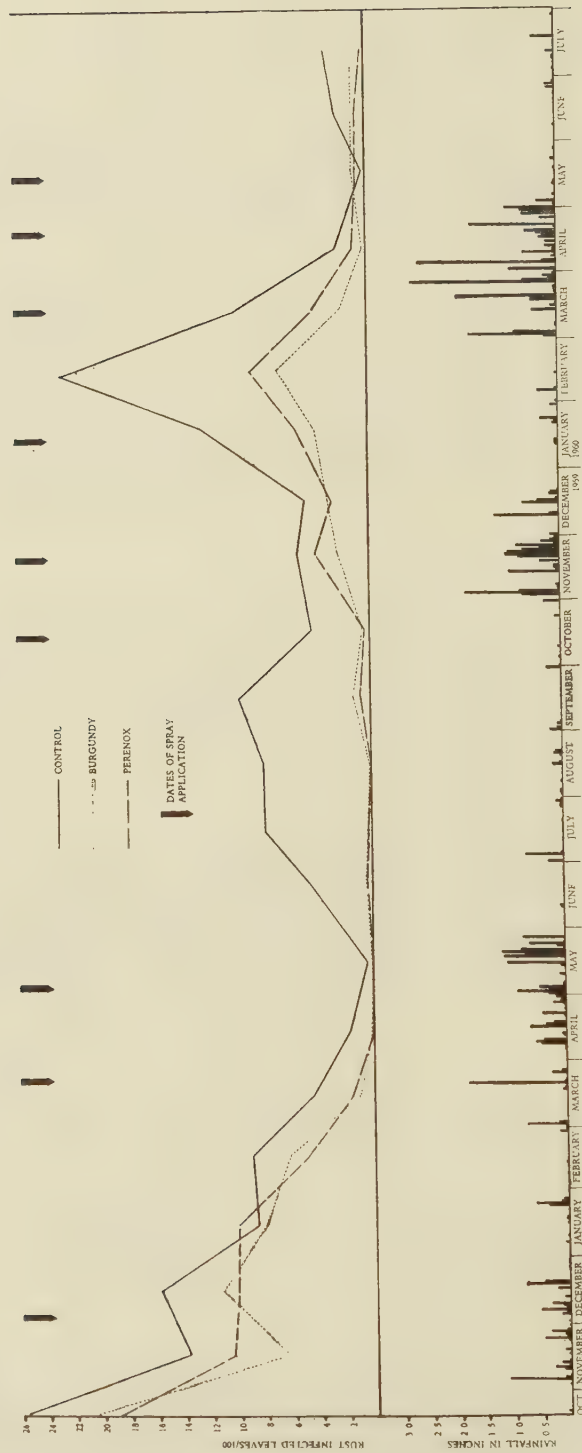


Figure 12

FUNGICIDES I

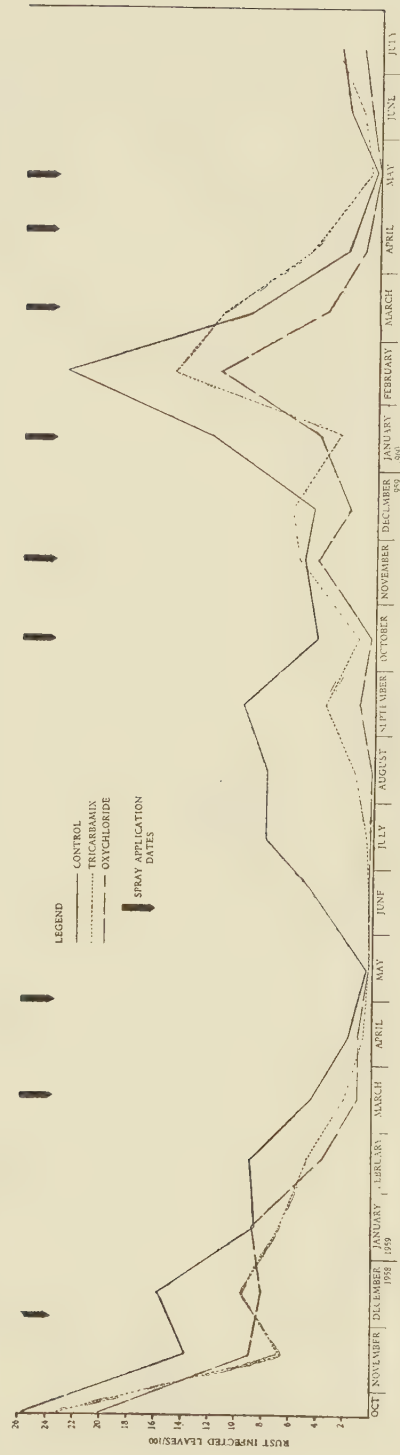
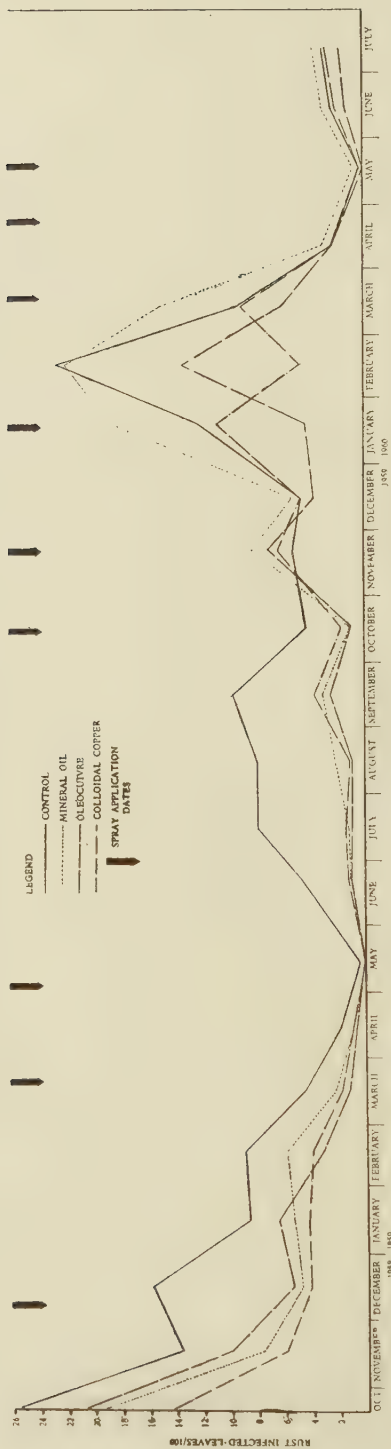


Figure 13

FUNGICIDES I



Fungicides II

The following fungicides were used:

Burgundy Mixture	..	..	..	..	..	..	Concentration 2%
Fungex (8% Cu as cuprammonium carbonate)	..	..	..	..	..	..	4 pt./100 gals.
Haft Vitigran (35% Cu as copper oxychloride)	..	..	..	..	..	..	10 lb./100 gals.
Cuprol 16 (16% Cu as copper oxychloride dust)	..	..	..	..	..	..	1 lb. per 60 trees

The dust was applied with a hand duster (Kyoritu Midget Duster) and the others with a Warley Eclipse as before. Figures 14 and 15 show the results graphically. The Rust level was extremely low so that the level of control achieved gave little idea of the potential efficiency of the fungicides. (See figures 14 and 15.)

Low-volume Spraying

An experiment commenced in March 1960 to compare high-, medium- and low-volume spraying for Leaf Rust control. The results of this work have been published in *Kenya Coffee* (October 1960), but will be briefly summarised here.

Using a Kiekens Whirlwind Mistblower (K.W.H. Type 75) the following treatments were applied. Although fungicides were applied precisely to each tree, the equivalent per acre can be calculated.

TABLE L

<i>Spray Volume</i>	<i>Per Tree</i>	<i>Per Acre</i> (trees at 8' × 8')
Vo Low	50 ml.	7½ gallons
V1 Medium	400 ml.	60 gallons
V2 High	800 ml.	120 gallons
<i>50% Copper Fungicide</i>	<i>Per Tree</i>	<i>Per Acre</i> (trees at 8' × 8')
Co Low	4 gm.	6 lb.
C1 Medium	8 gm.	12 lb.
C2 High	12 gm.	18 lb.

The experiment was of a 3 × 3 factorial design with an extra unsprayed plot in each of the three replications. There were therefore nine spray treatments, each spray volume (V) being used to apply each of the copper dosages (C). Each of the thirty experimental plots consisted of two rows of ten trees surrounded on all sides by unsprayed guard rows.

The copper sampling and assessments were carried out by members of the Colonial Pesticides Research Unit who have published their results in their Miscellaneous Report No. 269. The following table is derived from that report. The sample was taken immediately after spraying on 18th March.

TABLE LI
Initial Copper Deposit mg/m² on March 1960
(means of upper and lower leaf surfaces)

<i>50% Copper Fungicide</i> <i>per tree</i>	<i>Spray Volume per tree</i>		
	Vo 50 ml.	V1 400 ml.	V2 800 ml.
Co 4 gm. . . .	122	84	66
C1 8 gm. . . .	214	123	121
C2 12 gm. . . .	254	199	149

Continued on page 56

FUNGICIDES II

Figure 14

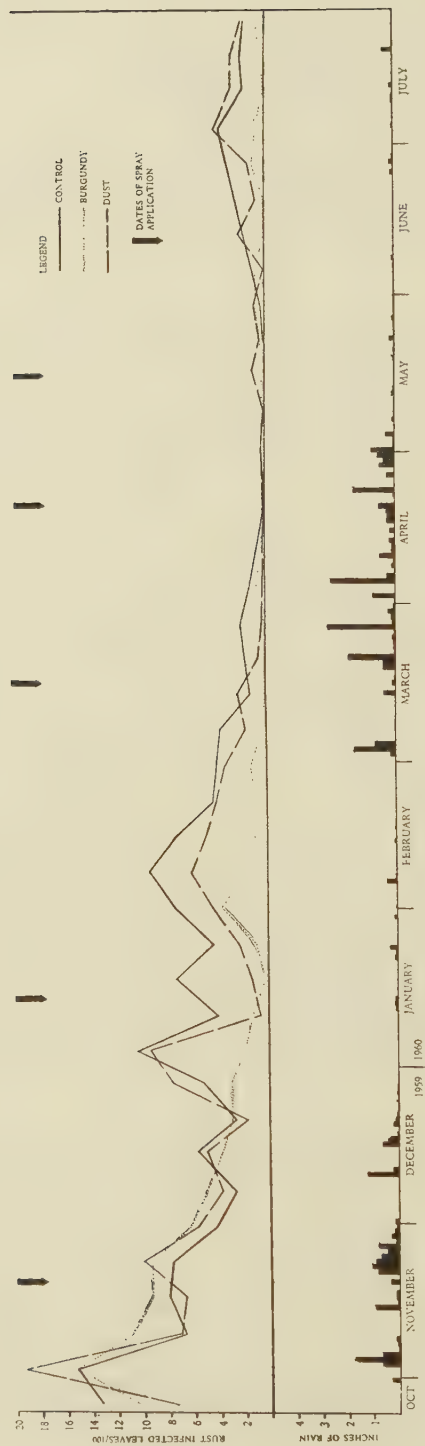


Figure 15

FUNGICIDES II



Figure 16

SPRAY VOLUME TRIAL

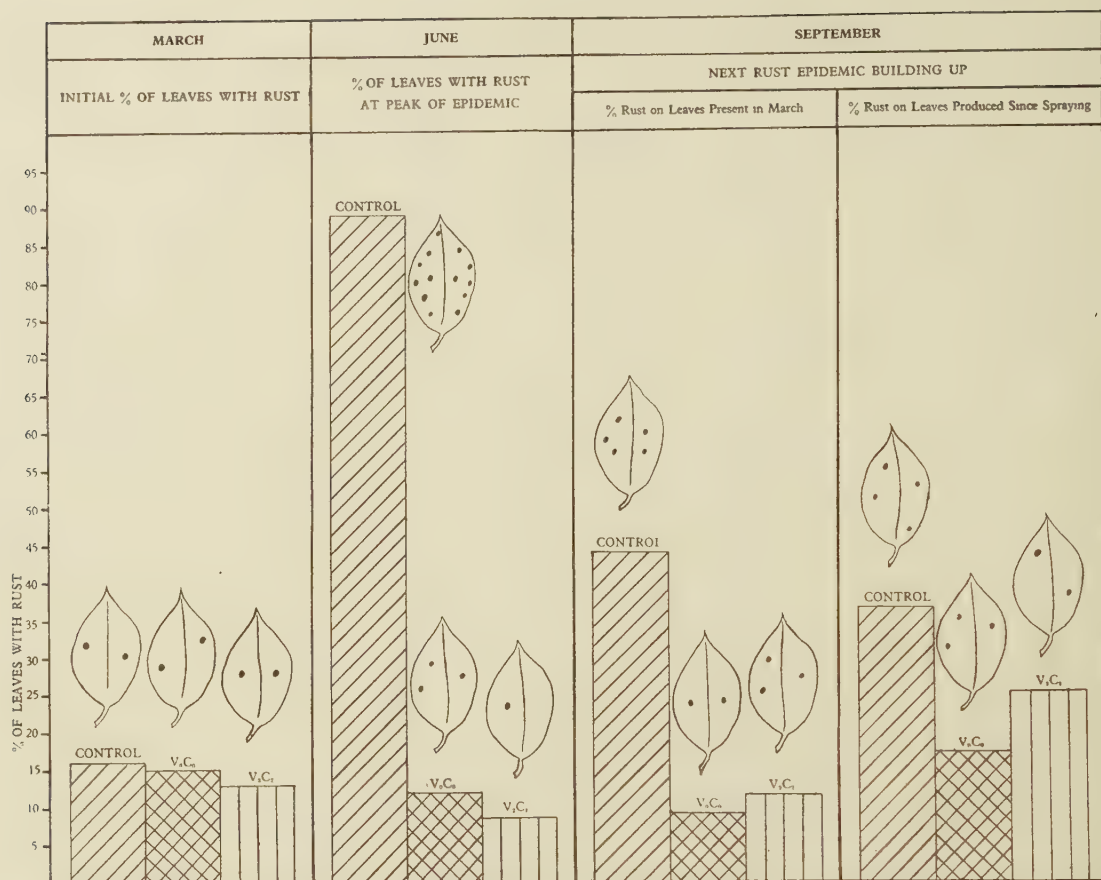


Figure 16 shows the initial level of Rust in the experiment at the time of spraying in March, and the level of Rust at the peak of the epidemic in June. Leaf diagrams indicate the average number of Rust lesions per rusted leaf. By observations on 600 marked primaries it was possible to record in September the Rust on leaves which were sprayed in March and on leaves produced since March and which were therefore unsprayed. The diagram shows how the Rust is building up on the unsprayed leaves.

As a consequence of this experiment, it is hoped to gain more experience in low-volume spraying for Rust control so that practical recommendations can be made.

Sampling for Rust

Due to the rapid build-up of Rust level from a minimum to a maximum in a period of a few weeks, it was thought desirable to take weekly leaf samples on all Rust trials. To take samples so frequently necessarily involves the use of small samples. In the above experiment five leaves per tree were collected each week. Thus from each 20-tree plot 100 leaves were collected and with three replications 300 leaves represented any one treatment. Data collected in this way were examined by the Statistician of the Agricultural Department and he has summarised his conclusions as follows:—

By taking two samples of 100 leaves from each plot, estimates of the experimental error variance and sampling error variance were found. Using these, the efficiency of the sampling methods can be compared with that of methods where larger samples are taken. It is found that, for the degree of replication used in the experiment, the sampling method was quite satisfactory and a treatment difference of 18% of the overall mean has a 50% chance of being detected. A difference of 47% would

be detected 95 times in a hundred. Increased accuracy can be obtained more easily by increasing the replication, rather than by increasing the sampling.

On a purely physical basis it is clear that the most efficient use of fungicide was obtained with the lowest volume of spray.

Table LII shows the position at the peak of the Rust epidemic in June.

TABLE LII
Percentage of Coffee Leaves with Leaf Rust 2nd June, 1960

50% Copper Fungicide per tree	Spray Volume per tree		
	Vo 50 ml.	V1 400 ml.	V2 800 ml.
Co 4 gm.	12	10	11
C1 8 gm.	9	9	9
C2 12 gm.	10	6	9
No significant difference			
Control (unsprayed) 89			

No significant difference was found between Rust levels on the sprayed plots so that, on both a physical and biological basis, the low-volume sprays gave the most efficient use of fungicide. The experiment also shows that 6 lb. of a 50% fungicide per acre should be adequate. Even when the quantity is applied in 120 gallons, satisfactory control results, and the Coffee Berry Disease Research Unit has reported adequate leaf Rust control using 5-7 lb. in 180 gallons. With this quantity of copper to be applied per acre, lower volumes of water gave larger dosages of copper per leaf in the present experiment, and indeed, the medium- and high-volume sprays resulted in considerable wastage of fungicide. The reasons for this are discussed in the C.P.R.U. Miscellaneous Report referred to above and are, briefly, that although more spray is hitting the leaves in the high-volume application, the amount of fungicide running off the leaves is greater. The threshold volume for wastage may vary with the type of machine used. Provided distribution is satisfactory therefore, it is indicated that low volumes will suffice for Rust control.

Irrigation Trial

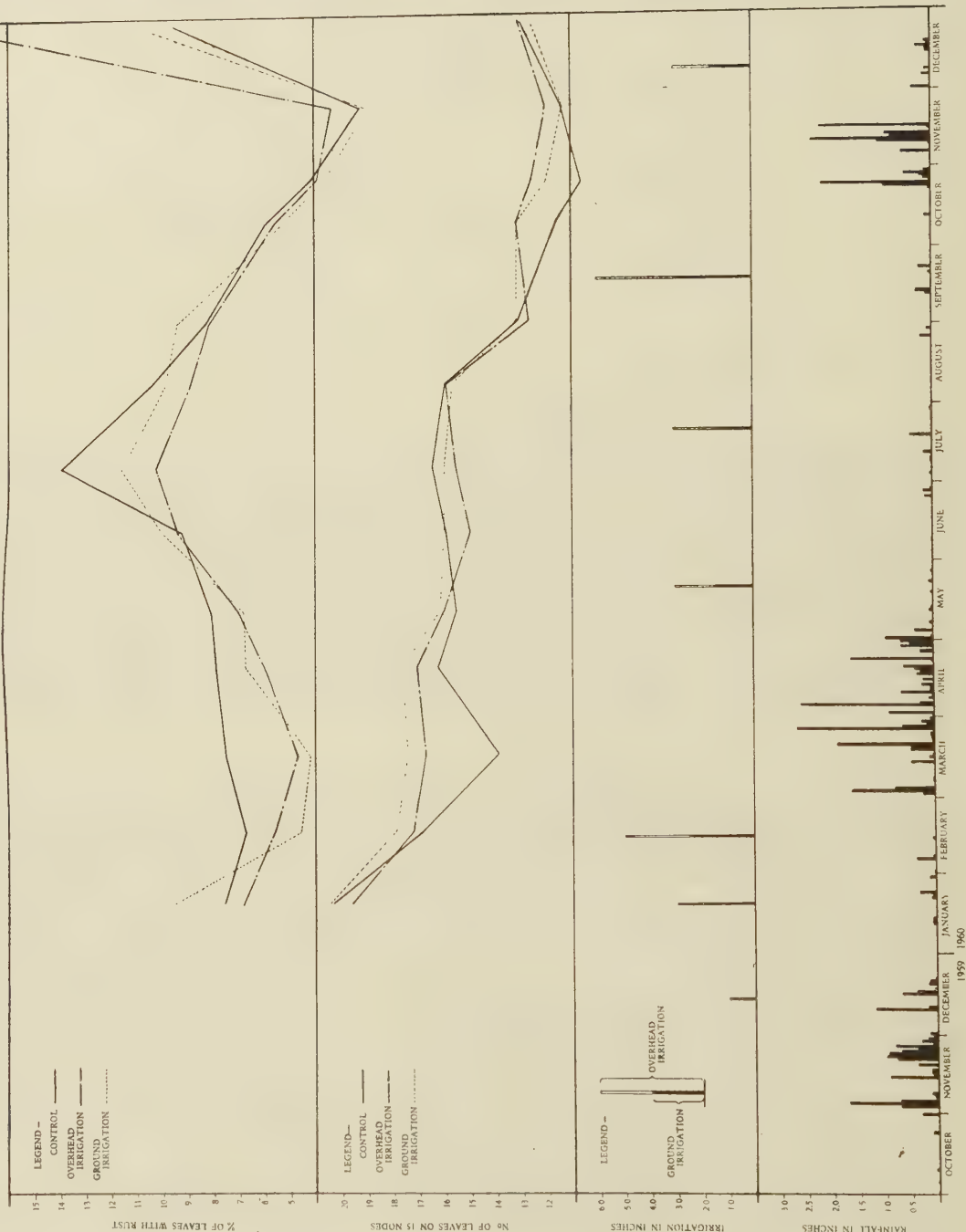
Observations were made throughout the year on the Irrigation Trial to compare the incidence of Rust on unirrigated control plots on ground and overhead irrigated plots. The Irrigation Trial receives each year the standard estate copper-spraying routine (i.e., in March, April, October and November, a 50% fungicide at the rate of 10 lb./100 gallons per acre, and May, 7 lb./100 gallons per acre). Irrigation is normally applied during the day. Under these conditions during 1960 no significant difference in Rust incidence was found. The method of assessing Rust was to count the number of leaves on the terminal 15 nodes of ten branches on each recorded tree, and to note the number of these with Rust and the number of Rust lesions. In this way, ten trees per plot were recorded, making a total of 90 trees in all (three treatments — three replications). This method also enables information to be obtained on the relative degree of foliation in the three treatments, as well as providing 2,000 or more leaves in each treatment for Rust assessment.

Various effects of overhead irrigation on Rust incidence could perhaps be expected. From the point of view of control, it has been suggested that irrigation may cause a favourable redistribution of copper, while on the other hand Rust spores may be distributed throughout the tree and germination may take place if leaves remain wet during the night.

Figure 17 shows details of rainfall foliation and Rust incidence as an average of three replicates and, although no significant differences were noted during the period January to November when all irrigation was during the day, there was a sharp increase in Rust on the overhead irrigated plots

IRRIGATION TRIAL

Figure 17



Elgon Dieback

In August, the Plant Physiologist and Pathologist visited the Trans Nzoia and Elgon Nyanza districts to investigate an outbreak of this condition and to decide on possible lines of study into its cause and possible control. The main findings of the visit were:

1. Elgon Dieback can occur at an altitude as low as 5,400 ft. in Elgon Nyanza:
2. There is no evidence that shade had prevented or reduced the incidence of the present outbreak:
3. Kapretwa Series "A" was fully susceptible to Elgon Dieback in the present outbreak:
4. Geisha was the only variety to show strong resistance to the disease:
5. While Elgon Dieback often followed hail damage, it was also found to occur in the absence of visible hail damage:
6. The symptoms in the field strongly suggested a disease caused by a fungal pathogen. Initial infection was usually at a node and commenced with blackening of the stipule:
7. The variable occurrence of the condition in the field suggested that, except under ideal conditions, infection is not easily accomplished and artificial inoculation experiments would be difficult.
8. It was by no means certain that the economic loss caused by the disease justified an extensive programme of Research.

In view of evidence recently published by Nutman and Roberts that the symptom of Elgon Dieback can be produced in the laboratory by inoculation with *Colletotrichum coffeanum*, a preliminary observation experiment has been laid down in the Trans Nzoia to attempt chemical control of the disease.

Soil Fumigation

It is frequently observed that there is a loss in seedling vigour in coffee nurseries which have been in use continuously, a decline which cannot usually be attributed to diminishing soil fertility or structure. Under such circumstances, the possibility of damage by eelworm or soil microflora, must be considered. In consequence, preliminary experiments to study soil fumigation are in progress. Marked stimulation of growth of seedlings has already been observed after fumigation treatment with D.D. After four months from the date of sowing seed, the average tap root length of seedlings from treated beds was 11.8 cm. while that of control seedlings was 5.1 cm. Moreover, while 43% of seedlings from treated beds had grown two true leaf pairs only 3% of the control seedlings had reached this stage of growth within four months. Whereas root systems from the treated plots had long fine laterals, separable from the soil with difficulty, the controls had a stubby truncated root system with many of the root endings club-shaped. To what extent the beneficial fumigation effect can be attributed to Eelworm control remains to be assessed. It is of interest, however, that the nematode fauna around control plant roots consisted almost entirely of Dorylamoidea. This problem is now being investigated more fully and a paper summarising present knowledge was read at the first Inter-African Plant Nematology Conference in October 1960. The problem of ascertaining the damage done by this type of nematode is, however, a formidable one and results achieved by partial soil sterilisation are not reliable evidence of nematode injury when unsupported by other evidence.

Seedling Disease

The symptoms of this disease have been described in *Kenya Coffee*. The fungus invariably associated with it has been identified as *Fusarium oxysporum*. Inoculation experiments with potted seedlings have failed to reproduce the symptoms of the disease, although the fungus can be recovered from the wood several months later. This confirms observations in the field which strongly suggest that only plants which have suffered from drought or other setbacks suffer from the disease.

Mist Propagator

Cuttings in the mist propagator have been destroyed by the fungus *Sclerotium rolfsii*. Within five days of noticing the first affected cutting, the fungus was found throughout the propagator and practically 100% loss of cuttings occurred. The rooting medium (sand and coffee hulls) was found to contain an average of one sclerotium per 10 grms. of the rooting medium. Routine testing of the rooting medium before it is put in the propagator is now carried out. The sclerotia can be easily observed by mixing the rooting medium with water; the sclerotia then floating to the surface.

ENTOMOLOGY

General Pest Situation

Leaf Miner was clearly the most destructive pest in all coffee areas East of Rift during the season, and many estates were compelled to spray several times during the course of the year. Lace Bug in these areas was perhaps less prevalent than in recent years, but still caused a considerable amount of damage during the hot season, whilst Stinging Caterpillar was the only leaf-eater to cause widespread damage East of Rift. In West of Rift coffee, *Antestia* remained the dominant pest and some outbreaks of Tailed Caterpillar were reported. Only one species of Leaf Miner, *Leucoptera meyricki* Ghes., occurs West of Rift where it seldom causes severe damage.

Research Programme

The year has been largely one of consolidation. Several small projects have been brought to, or near, the stage when they can be written up for publication. A comprehensive set of leaflets and line drawings covering 24 coffee pests has been completed.

Both Leaf Miner and *Antestia* received a considerable amount of attention during the year; in 1961/62 it is planned to intensify work on the biology and control measures of the former.

Below are given the results of work during 1960/61 under individual pest headings.

Leaf Miner. *Leucoptera meyricki* Ghes. and *L. coffeina* Washb.

Damage was particularly severe during the last six months of 1960, but a high level of infestation has continued on a few estates right up to the time of writing. It would appear that, although the general picture is one of an annual build-up reaching a peak around November, followed by a rapid decline in population, heavy infestations, usually of a limited nature, can occur at any time of the year.

No insecticide has yet come to hand which appears likely to displace diazinon, parathion or methyl parathion for the control of mining larvæ. A trial with diazinon in different volumes of spray per acre applied by knapsack sprayer gave indications that the high volumes gave better control of larvæ, but further work is required on this point before concrete recommendations can be made. Some failures in the control of larvæ with parathion wettable powder were reported during the year. Investigations are still continuing and sufficient data are available to state that a dosage of less than 2 lb. of 20% parathion wettable powder is insufficient to give adequate control of this stage. However, this work is incomplete at present and it is likely that recommendations for Leaf Miner control will be changed when further experimentation yields a better understanding of this pest.

Progress has been made towards developing a technique for rearing Leaf Miner in the laboratory to enable work to be carried out on problems related to insecticidal control which cannot be studied in the field. Picked coffee leaves have proved rather unsatisfactory for rearing purposes, apparently due to lack of sufficient food supplies in the leaf, which turns yellow soon after mining commences. The alternative of using potted seedlings, however, shows considerable promise.

Twenty-eight species of Hymenopterous parasites have now been bred from the two *Leucoptera* spp. With Mr. R. G. Tapley of the Coffee Research Station, Tanganyika, a joint publication is planned in which will be listed the recorded parasites of *Leucoptera* spp. found in East Africa.

A special study of the integration of biological and chemical control of coffee pests is being made by Dr. Bess during his nine months' Fulbright Scholarship at the Coffee Research Station. The study was begun in September 1960 and involves weekly measurements of the population of pests, especially Leaf Miner and its parasites, in sprayed and unsprayed coffee. The findings obtained so far indicate that insecticides kill Leaf Miner more readily than the parasites inside the mines. There are several complicating factors, such as the proper timing of spray applications. There are good indications that parasitisation may be increased by the judicious use of certain insecticidal sprays.

Antestia. *Antestiopsis lineaticollis* Stal.

A full account of the pyrethrum/D.D.T. method of control has been accepted for publication in the *Bulletin of Entomological Research* and will probably appear in 1961. A brief account of the method appeared in the June 1960 number of *Kenya Coffee*. Gelatine capsules containing 5 ml. of 10% pyrethrins and 10% synergist became commercially available during the year. One capsule in one pint of kerosene was found to be fully equal to the home-made double-strength pyrethrum extract used in the past.

A trial was carried out to compare the standard pyrethrum treatment (high volume) with low-volume sprays. The results showed that 20 gallons of 0.012% pyrethrins per acre gave comparable control to the standard 80 gallons of 0.006%, at only half the cost.

White Waxy Scale. *Ceroplastes brevicauda* Hall

The main features in the life history of this Scale have been elucidated. There are two generations a year at Jacaranda, maturity being reached during the two main rainy seasons. Eggs are found under the carapace of the Scale; on hatching the crawlers take up a position on hardened leaves, mostly along the main veins and more frequently on the upper surface. The first two instars are passed here. The Scales then migrate from the leaves to adjacent green shoots where they remain for the rest of their lives.

The Scale can be controlled if detected while still on the leaves, a stage which usually occurs in July and February. Two and a half per cent white oil and malathion 0.15% a.i. have proved effective as high-volume sprays against the first two instars.

Waxy Scales from West Rift have been identified provisionally as *Ceroplastes destructor* Newst. If this is confirmed it will be the first record of this cosmopolitan species from coffee in Kenya.

Star Scale. *Asterolecanium coffeae* Newst.

Treatment of affected bark with 5% Tar Oil has given excellent control on an estate scale, although it has been found essential to apply Tar Oil only on a hot dry day to facilitate good absorption by the bark. Scales feeding on primaries are not treated but are quickly cleared up by parasites.

Lace Bug. *Habrochila ghesquierei* Schout.

Work in Uganda has clarified the confusion between *H. ghesquierei* and *H. placida*. The former appears to be confined normally to *Coffea arabica*. Since observations in the literature on the life history of *H. ghesquierei* are suspect, further field studies are being made at Ruiru. The egg period has been found to vary from 18 to 32 days and the nymphal period from 16 to 36 days. In addition a pre-oviposition period of over seven days has been observed. When records have been completed, revised spray timing recommendations will be issued.

Sprays of 0.02% a.i. parathion have given excellent control of nymphs and adults. Lace Bug has not yet extended its range into Machakos and Meru districts.

Green Scale. *Coccus alpinus* De Lotto

Identities of Green Scales occurring on coffee in Kenya have been clarified by De Lotto. The common species infesting *Coffea arabica* has been described as *C. alpinus*, a new species. A further new species, *C. viridulus*, was collected from *C. arabica* in the Nandi Hills.

Thrips. *Diarthrothrips coffeae* Williams

No widespread outbreak of Thrips occurred during the hot season in the first quarter of 1961, but the few localised outbreaks which did occur caused severe damage owing to the droughted condition of the trees at the time.

Leaf Skeletonizer. *Leucoplema dohertyi* Warr.

This species was less in evidence during the past year than in any year since 1955. A short account of its biology was published in *Kenya Coffee*, July 1960.

Berry Moth. *Prophantis* (*Thliptoceras*) *smaragdina* Butler

Routine trapping of this species continued at Makuyu, but no large build-up occurred during the year.

Fruit-Piercing Moths. *Othreis materna* L. and other spp.

An attack by these pests was recorded for the first time in Kenya in the Makuyu/Mitubiri area. Investigations showed that the moths pierced full-sized green berries at night, causing premature ripening. The moths were attracted to pineapple, but pineapple baits gave variable results in controlling the pest. From a study of damage to citrus in the area, it appeared that populations of these moths built up to abnormally high numbers in March–April 1961. Attacks of this severity may be expected to occur rarely and infrequently.

Looper Caterpillar. *Ascotis reciprocata* Janse

This new, but apparently very minor, pest caused some damage to seedlings and mature trees at Jacaranda. Details of its life history are being worked out.

Tip Borer. *Eucosma nereidopa* Meyr.

Counts continued during the year at several sites in Upper Kiambu confirming that 2% D.D.T. applied to the trunks of shade trees gave an excellent and economic control. A full account of the biology and control of this pest will be written up and will probably appear in print during 1961.

Yellow-Headed Borer. *Dirphya nigricornis* Ol.

The pyrethrum/kerosene mixture used for Antestia test-spraying has been found to give good control of larvæ when injected into their tunnels. A full account of the biology and control of this pest will probably be published in 1961.

White Borer. *Anthores leuconotus* Pasc.

No further surveys or campaigns have taken place during the current year. Planters now treat their coffee with $\frac{1}{2}$ % dieldrin at their own discretion. The fact that this is an effective insurance against attack by beetles from the bush and adjacent estates is now widely appreciated.

Anthribid Borer. *Phlæbius pustulosus* Gerst.

Stems of young coffee containing boring larvæ were received from the Meru district in October. A visit in November revealed that, although many trees were dying, this was due primarily to prolonged drought superimposed on poor root development. Healthy trees were not attacked by *Phlæbius*.

This is the first outbreak of this pest since the damage was described in "Coffee in Kenya" in 1937. A few specimens were collected by A. R. Melville in 1955 at Thika and D. J. McCrae recorded observing the typical damage on exposed surfaces where old verticals had been cut off on coffee in Makuyu.

Berry Borer. *Stephanoderes hampei* Ferr.

A few infestations of Berry Borer have been reported on African-grown *Coffea canephora* and *C. arabica* in the lower regions of Nyanza Province. Frequent picking, sanitation measures and dieldrin sprays are the recommended control measures.

Mites

Four species of phytophagous mites have been recorded from coffee in Kenya. These are *Oligonychus coffeae* (Nietner), *Brevipalpus phenicus* (Geijskes), *Hemitarsonemus latus* (Banks) and *Diptilomyopius* sp. The first of these species has caused appreciable damage to young coffee at Jacaranda and has been seen in moderate numbers on a few estates in hot dry areas; a close watch is being kept on this species as a potentially important pest. Current information on these four species was summarised in the December 1960 issue of *Kenya Coffee*.

Taints

There were several reports of "bricky flavour" from Thika and Fort Hall districts during the year. The cause appeared to be drift of BHC sprays from aircraft spraying a swarm of Desert Locusts in February 1960.

Reports of "grassy flavour" are being investigated as they occur. Similar off-flavours in other countries are spread by insects. To date, reports of "grassy flavour" have been too few to enable a thorough investigation to be made.

RESEARCH ON COFFEE PROCESSING

Mr. A. E. Wootton, Senior Scientific Officer, East African Industrial Research Organisation, continued his investigations into the problem of "onion flavour". Mr. Wootton has contributed the following report summarising his findings.

Onion Flavour Investigations

The work on the nature and cause of onion flavour in Kenya coffee as detailed in the East African Industrial Research Organisation's Report C.R.11 was continued during the year.

In C.R.11, onion flavour was shown to be correlated to the incidence of propionic acid during fermentation. The conditions conducive to the development of this acid were demonstrated. As a result it was tentatively concluded that the incidence of onion flavour could be reduced or eliminated by either a reduction in fermentation time or a reduction in the extent of pre-washing.

One European estate previously troubled by persistent onion flavour reports having eliminated the taint by a 24-hour reduction in fermentation time, although, by prolonged fermentation in the laboratory, it was still possible to obtain badly tainted coffee. During the 1960 off-season, the pre-washing channel at the factory was blocked off and pulped beans were transferred to fermentation tanks via a simple vortex device, which separated lights and skins from good coffee using very little water. As anticipated, lactic and acetic acids were produced in relatively high concentrations during fermentation with a consequent low pH. Even after a 48-hour continuation of fermentation in the laboratory, no propionic acid appeared at all, and no onion flavour was reported for the final liquor.

The African Co-operative factories in the Embu area were encouraged to reduce fermentation time from a minimum of 84 to a maximum of 72 hours. Judging from the liquoring reports a marked fall in onion flavour incidence followed. This is shown in the following table. The onion flavour factor is calculated by ascribing three points to a "bad onion flavour" report, two points to "onion flavour" and one point to "suspicion of onion flavour" and then totalling the points for each month and expressing them as points per 100 out-turns.

<i>Month</i>	<i>"Onion Flavour" Factor</i>
1960 August	118
September	188
October	116
November	28
December	17
1961 January	30

The change in fermentation time occurred towards the end of August; the time lag between fermenting and liquoring is of the order of two months and considerable reduction in the factor is noticeable between October and November, during which time it might reasonably be assumed that coffee fermented for 72 hours only was beginning to reach the mills.

It is perhaps early to claim that the success is due entirely to the reduced fermentation time, but the results are certainly encouraging.

Either of the recommended changes in the fermentation conditions might well alter the final coffee quality, apart from affecting the taint. Accordingly a different approach to fermentation has been initiated. Investigations have begun in an attempt to discover the most suitable conditions for fermentation; in order to do this a technique for the measurement of protopectin in the mucilage around the bean has been successfully developed and it is therefore possible to follow the rate of mucilage breakdown during fermentation and so to determine the effects of pH, temperature, pre-washing, etc., upon the rate of fermentation with some precision.

By the addition of propionic acid to the fermenting coffee from an estate with no onion flavour history, it was found possible to obtain coffee "foul with onion flavour". This suggests that the taint is not dependent upon the processing of susceptible coffee. A similar attempt to produce onion flavour failed, however. Clearly the full story is not a simple one.

As a result of the findings reported in C.R.11 and of work conducted at the Coffee Research Station, which indicated that under-ripe coffee was more likely to be affected by onion flavour than ripe, it appeared that the measurement of sugars in coffee cherry should prove valuable. Initial studies of the sugars present in coffee cherry indicated that the concentrations of both reducing sugars and sucrose increased with maturation. A further, more detailed, investigation into this aspect has already begun and the results so far support the early work.

Other Investigations

Using two ventilated bins built at Jacaranda for research purposes an experiment was conducted in an attempt to establish the limits to which bins may be used before causing a loss in quality.

Further experiments on ventilated bins were conducted at Kituamba Estate, Kiambu, by kind permission of Mr. T. K. Twist.

Mr. I. M. Johnson (Agricultural Engineer, Department of Agriculture) made further progress with the Stage I drying problem. An improved version of the Cascade Drier, designed by him and tested at Ibonia Estate in 1959 was constructed, installed and tested at Njuno Estate, Kiambu, by kind permission of Mr. B. M. Aagaard. The drier was demonstrated to members of the Coffee Processing Sub-Committee and subsequently discussed at Njuno Estate on 1st December, 1960.

Further experiments on picking coffee in various stages of ripeness were carried out at Jacaranda. An investigation to seek a correlation between the colour of the cherry skin and the maturity of the coffee bean was initiated by Dr. Wormer.

A preliminary investigation into coffee fermentation in tanks with and without skins was started at Jacaranda. The purpose of this investigation is to try and establish whether or not there is any great advantage to quality by pre-washing, as it is now known that excessive pre-washing is a contributory cause of onion flavour.

COFFEE GROWING IN AFRICAN AREAS

The volume of crop produced by African coffee-growing areas increased from 4,607 tons in the 1959/60 crop season to 7,770 tons in the 1960/61, an overall increase of 68.5% in one year. Although weather conditions were unfavourable for the production of quality coffee in some African coffee areas, a few districts such as Kangundo/Machakos, Elgon Nyanza, Embu and Nyeri did produce some excellent quality coffee. The early crop in Meru was of poorer quality than normal because of the extremely dry weather conditions which prevailed from early May until the end of October. Good rains were received in this important African coffee area in November and December and this was reflected in the good quality Meru coffee produced from the December and January pickings.

Improved Agricultural Methods

During the year the field extension officers of the Department of Agriculture devoted a great deal of time to the introduction of modern agricultural methods and techniques. Nitrogenous fertilizers were used in substantial quantities in some African coffee areas of Central Province for the first time. Owing to the high cost and doubtful quality of farmyard manure available in African areas, the stimulation of demand for nitrogenous fertilizers received a high priority.

The organisation of spraying teams and re-equipment of these teams with improved spraying machinery also gathered momentum during the year. A wide range of spraying equipment had been previously tested in difficult terrain in Meru district and recommendations as to suitable equipment were based on the results of these trials. Coffee Berry Disease (*Colletotrichum coffeanum*) continued its advance around Mount Kenya and northward through Meru district. It is clear that high-volume spraying equipment will now be needed throughout the Central Province to combat the ravages of this disease. If current research finally proves that low-volume sprayers are effective in controlling Leaf Rust (*Hemileia vastatrix*) this will simplify spraying organisation considerably in the Leaf Rust endemic zones. Many of the difficulties of spraying scattered small coffee shambas in difficult terrain are directly attributable to transportation of the large volumes of water necessary. Water bowsers attached to tractors were used in the Meru experiments, the water being discharged into 44-gallon drums. The haulage of water is an expensive undertaking, however, and any reduction in the volume of water required for fungicidal sprays is very welcome.

Coffee Drying

Excellent coffee cherry can be ruined by poor factory work and inadequate drying facilities. With the substantial increase of crop in many factories it was necessary to advise the Coffee Co-operative Societies to improve their drying facilities. A few bed driers were installed into some of the larger factories in Meru district but the acreage of tables for sun-drying was expanded rapidly. Difficulties are frequently experienced during the dull cloudy weather which occurs from June till August in parts of the Central Province and because of this some resort to mechanical drying will become increasingly necessary. A few ventilated conditioning bins will be used for the first time during the 1961/62 crop season.

The Kisii highlands also experienced great difficulty with drying a large crop. In this area sun-drying of coffee will probably continue to be used exclusively owing to the high capital cost of installing mechanical driers.

Coffee Factory Construction

Construction of new factories continued apace during 1960 and, by early February, there were 115 factories erected in Central Province. It was noticeable that an increased number of factories were being erected without pre-washing channels, the Aagaard pre-grader being used in place of a pre-washing channel. This development is important because with the constantly increasing number of factories some conservation of water consumption will become necessary. The Aagaard dry feed and Aagaard pre-grader are certainly more economical than the traditional syphon feed and pre-washing channels in the amount of water required to produce a ton of washed parchment coffee.

In the Machakos district, where water is often in short supply, the Aagaard-equipped factories are standard throughout the district. The absence of a pre-washing channel is definitely not detrimental to the production of good quality coffee and it is interesting that no known case of onion flavour has yet been associated (in the African coffee areas) with coffee produced from factories without pre-washing channels.

Coffee Variety Trials

Results obtained from Variety Trials in African areas are included in the appropriate section of Field Investigations. In addition, a considerable amount of information, mostly of an observational nature, has been obtained. Sufficient knowledge has now been secured from coffee Variety Trials in many districts to be able to recommend with confidence the variety or varieties particularly suited to a climatic area.

Between 5,200 ft. and 6,000 ft. throughout Central Province, the high-yielding and excellent quality liquoring varieties SL28 and SL34 have been outstanding. The variety SL34 is preferred for planting at higher altitudes approaching 6,000 ft. where the growth abnormality known as "Hot and Cold" usually occurs. In areas between 5,200 ft. and 5,700 ft. SL28 is particularly suitable and has been outstanding in the Miiiriga Mieru (Meru district) Variety Trial (5,500 ft.); here an average annual yield of 19.75 cwt. of clean coffee has been obtained since 1954.

In the Leaf Rust (*Hemileia vastatrix*) endemic areas of Nyanza Province (below about 5,200 ft.) and in Coast Province (Teita district below 5,400 ft.) the ability of coffee varieties to resist Leaf Rust is of paramount importance. Where only Race II of Leaf Rust occurs the varieties K7 and SL6 have been outstanding in Variety Trials; seedlings of both these varieties are now being planted extensively. A far more complex situation exists in areas where both Race I and Race II of Leaf Rust occurs. Several of the Indian S and BA series are known to be immune to Races I and II, but insufficient information on potential yield and liquoring quality is available at present to permit recommending the planting of these varieties on a commercial scale. Individual tree variation within the S and BA selections is considerable: consequently some re-selection will probably prove necessary before release for commercial use.

Where Coffee Berry Disease (*Colletotrichum coffeanum*) is widespread and is known to cause heavy crop losses the variety Blue Mountain is advised because of its resistance, albeit of limited degree, to the disease. In South Nyanza district only Blue Mountain is planted above the 5,600 ft. level. Although other varieties, such as SL28 and SL34, have a heavier cropping potential their yielding ability cannot be realised unless a full programme of sprays to control Coffee Berry Disease is efficiently applied.

Coffea canephora (Robusta)

The Robusta pruning and spacing trial planted in 1958 at Busia (Elgon Nyanza district) produced a first small crop in 1960. Valuable information has been obtained concerning the vital necessity for shelter belts and shade trees. Without these, successful growth of Robusta in Nyanza Province is virtually impossible because of the serious incidence of "Crinkle Leaf". Tests are in hand to determine if wet-processing of Robusta cherry can yield a market premium (over sun-dried cherry) sufficient to warrant the erection of small pulperies to process the crop.

Coffea excelsa

The trial of *Coffea excelsa* at Ishiara, Embu district (2,900 ft.), continued to grow well despite the excessively dry conditions which prevailed during 1960. This species of coffee grows naturally on single or double heads, does not sucker freely and the habit of bearing on mature wood favours the adoption of a true single-stem system. Pruning is confined to removal of dead wood and of primaries in contact with the ground. As with Robusta in Nyanza Province the provision of shelter belts to reduce exposure is all-important. At Ishiara overhead shade of *Sesbania punctata* for the initial years after planting, and shelter belts of giant *Leucaena*, have had a most marked effect upon tree growth.

A small commercial development of *Coffea excelsa* is proposed at Ishiara. It is anticipated that 25-30 acres will be established in the first instance, from which the cherry will be pulped and fermented.

RUKERA DEMONSTRATION FARM

Development

There were no capital improvements in the form of buildings or machinery during the year under review.

Development of the coffee areas at the top of the estate was concluded; stretches of the access roads were realigned, entailing some two acres being added to plot fringes.

The first plot scheduled for replanting was planted in March 1960, after detailed planning carried out by the Soil Conservation Service. The plan involved construction of new roads, drainage ways and terraces. A total acreage of 8.3 acres was planted on the contour at a spacing of 10 feet by 8 feet, 2.3 acres of the variety K.7 and the remainder S.L.34. Coffee on steep and shallow soil at the lower end of the farm was uprooted as soon as the crop had been picked. This area, some five acres in extent, will be utilised for leys of Rhodes grass.

1960-61 Crop

Rainfall: 1.1.60 to 31.12.60 (inches)	.	.	.	.	.	.	.	.	.	32.48
Acreage in production	.	.	.	.	.	.	.	.	.	82.76
Clean coffee (tons)	.	.	.	.	.	.	.	.	.	35.80
Average per acre (cwt.)	.	.	.	.	.	.	.	.	.	8.50
Mbuni (lb.)	.	.	.	.	.	.	.	.	.	14,018

<i>Classifications</i>	<i>lb.</i>	<i>Percentage</i>
Class 3	12,608	17.37
Class 4+	14,069	19.38
Class 6	24,518	33.78
Class 7	4,766	6.57
Class 8	482	0.66
Class 9	8,563	11.80
Class 10	1,011	1.40
Class 11	4,950	6.82
Class 12	667	0.92
Class 13	942	1.30
	<u>72,576</u>	<u>100 00</u>

12,710 lb. of parchment were prepared as coffee seed from clonal trees of S.L.28 and S.L.34. A clean coffee allowance for this has been added to the total weight of crop shown above.

The average basic scale price of the crop was 75.2 cents per pound calculated without addition of bonus.

Other Enterprises

During the year 10,410 lb. of Washington Navel oranges were picked from two acres of trees, realising an average price of 12 cents per pound. The small acreage of Naartjies planted in 1958 has made excellent growth and promises to become a worthwhile addition to the citrus acreage.

After some severe culling last year the standard of the Guernsey herd has greatly improved, although milk yields have been somewhat affected by the two periods of prolonged dry weather. A further six head of female stock were culled and sold during the year.

Farm Accounts: 1959/60 Season

A falling market price coupled with rising costs of production diminish the profit margin, creating growing interest in this aspect of the farm's objectives. In the last edition of this report production costs and related figures were briefly reviewed for the 1958/59 season and compared with the two previous seasons. Similar tables, which enable direct comparison to be made, are included again for the 1959/60 season.

(1) *Sales:*

In 1959/60, the estate produced 23.95 tons of clean coffee which yielded £9,109 or £380 per ton after deducting curing and selling charges. The average yield was 6.16 cwt. per acre from 83.28 acres (excluding seed production areas). Seed production plots of 9.9 acres yielded 5,853 lb. of seed to a gross value of £2,195 (in addition to a quantity of parchment coffee).

(2) *Cost of Production:*

Table LIII shows the cost of production for the past three seasons, expressed as crop expenses per ton (the components of which are enumerated in Table LV), the coffee maintenance, overhead expenses and depreciation.

The cost of production per acre for the year was a little higher than in 1958/59, but lower than in other previous years, due to a rise in overhead expenses. All components of the latter increased except office and sundry expenses. Examination of the relative net profit figures for the past four years shows that the profit margin per acre continues to decline from the level reached in 1957/58, despite a higher crop yield than in 1958/59, viz:

1956/57: £ 8,465.7 from 74 acres or £114.4 per acre.

1957/58: £10,355.8 from 78 acres or £131.5 per acre.

1958/59: £ 5,235.5 from 87.4 acres or £59.9 per acre.

1959/60: £ 4,203.5 from 83.3 acres or £50.5 per acre.

(3) *Cost of Varying Levels of Production:*

Based upon the production costs for the 1959/60 season Table LIV illustrates the comparative costs at varying yield levels. This may be compared with an equivalent Table included in last year's annual report, showing the importance of overhead expenses as an element of cost, particularly at lower production levels. Whereas the net profit at the six-cwt. yield level in 1958/59 was £146 per ton, in 1959/60 the margin was £93 per ton, most of the difference being due to a lower average unit value of the crop. Comparable accounts are not yet available for the 1960/61 year, but it is clear that the further fall in the average price which has occurred (of £60 to £70 per ton) will accelerate this trend in the profit margin.

(4) *Analysis of Crop Expenses and Coffee Maintenance Costs:*

An accurate breakdown of operation costs for the year is shown in Table LV.

Crop expenses include all costs incurred in picking and processing the crop. The unit cost per ton is very similar to the previous year, higher picking and labour rates being offset by a bigger crop and a shorter processing season.

Although the unit cost per acre of coffee maintenance is at a very similar level, most of the operations differ in cost when compared with the previous year, due to varying reasons.

Among routine operations the cost of mulching is of particular interest. Table LVI shows the breakdown of Napier Grass Expenses given in the preceding Coffee Maintenance Table. It should be noted that the total acreage of Napier grass is 37 acres, which provided mulch for 30 acres of coffee. Thus a different divisor for unit acre cost is used in the two Tables. The cost of the first year's development of five acres of new land for Napier grass production is also included in the Table.

TABLE LIII
Cost of Production

	1959/60 Acreage—83.28 Crop—25.65 tons Yield per acre: 6.16 cwt.		1958/59 Acreage—82.4 Crop—22.675 tons Yield per acre: 5.5 cwt.		1957/58 Acreage—74 Crop—28.40 tons Yield per acre: 7.6 cwt.	
	Per acre	Per ton	Per acre	Per ton	Per acre	Per ton
(a) Crop Expenses	—	£ 53.73	—	£ 55.08	—	£ 49.51
(b) Management Commission	—	£ 7.37	—	£ 9.93	—	£ 17.70
(c) Coffee Maintenance	£ 19.96	£ 64.82	£ 21.27	£ 77.34	£ 28.52	£ 75.05
Overheads	£ 38.97	£ 126.52	£ 30.48	£ 110.83	£ 45.71	£ 120.28
Depreciation	£ 8.82	£ 28.64	£ 11.05	£ 40.18	£ 6.50	£ 17.10
	<u>£ 67.75</u>	<u>£281 08</u>	<u>£ 62 80</u>	<u>£293 36</u>	<u>£ 80.73</u>	<u>£279 64</u>

TABLE LIV

Cost at Varying Levels of Production 1959/60 Crop. Cost per Ton

<i>Yield per acre</i>	<i>3 cwt.</i>	<i>4 cwt.</i>	<i>5 cwt.</i>	<i>6 cwt.</i>	<i>7 cwt.</i>	<i>8 cwt.</i>	<i>9 cwt.</i>	<i>10 cwt.</i>
Crop Expenses	£ 53.73	53.73	53.73	53.73	53.73	53.73	53.73	53.73
Management Commission	£ 7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
	£ 61.10	61.10	61.10	61.10	61.10	61.10	61.10	61.10
Maintenance	£133.09	99.82	79.85	66.54	57.04	49.91	44.36	39.92
Overheads	£259.78	194.83	155.87	129.89	111.33	97.42	86.59	77.93
Depreciation	£ 58.80	44.10	35.28	29.40	25.20	22.05	19.60	17.64
	£512.77	399.85	332.10	286.93	254.67	230.48	211.65	196.59

TABLE LV

<i>Crop Expenses Analysed 1959/60 Crop (25.65 tons clean coffee)</i>			<i>Coffee Maintenance 1959/60 Crop (83.28 acres)</i>		
	<i>Total</i>	<i>Cost per ton</i>		<i>Total</i>	<i>Cost per acre</i>
	<i>Shs.</i>	<i>Shs.</i>		<i>Shs.</i>	<i>Shs.</i>
Picking	15,494.36	604.07	Weeding/Cultivation	5,504.28	66.09
Stripping	922.01	35.95	Couch Control	1,820.87	21.86
Transport	358.27	13.97	Pest Control	684.57	8.22
Factory Expenses	5,793.79	225.88	Anti-Rust/Tonic Spray	4,193.48	50.35
Bags and Twine	229.47	8.95	Fertilizing	7,650.73	91.86
Transport to Mills	403.35	15.72	Pruning	2,654.26	31.87
Upkeep Machinery	1,762.96	68.73	Handling	2,799.31	33.61
Upkeep Drying Lines	1,124.65	43.85	Soil Conservation	691.68	8.30
Supervision (Wages)	1,121.54	43.72	General Transport	57.54	.69
Water Factory	184.00	7.17	Sundry Expenses	150.62	1.80
Sundry Expenses	168.36	6.56	Napier Grass Expenses	7,046.48	84.61
Shs.	27,562.76	1,074.57	Shs.	33,253.82	399.26

TABLE LVI

<i>Napier Grass Expenses (37 acres)</i>			<i>Napier Grass Development (5 acres)</i>		
	<i>Total</i>	<i>Cost per acre</i>		<i>Total</i>	<i>Cost per acre</i>
	<i>Shs.</i>	<i>Shs.</i>		<i>Shs.</i>	<i>Shs.</i>
Cultivation/Weeding	2,324.99	62.83	Land Preparation	124.76	24.95
Fertilizing	968.01	26.16	Planting	1,463.96	292.79
Cutting	873.18	23.61	Fertilizer Manure	975.25	195.05
Couch Control	89.99	2.43	Cultivation	305.05	61.01
General	8.78	.23	General	130.41	26.08
Transport and Spreading	2,781.53	75.17			
Shs.	7,046.48	190.43	Shs.	2,999.43	599.88

Mulching 30 acres of coffee Shs. 243.88

SUBSTATIONS

The process of developing the substations at Kisii, Meru, Upper Kiambu and Koru was approaching completion by the end of the year. The field trial programme for Upper Kiambu was in full operation and was nearing this stage at Kisii and Meru. In all cases the results from field experiments are included in the chapter on Field Investigations.

Kitale Experimental Station

1960/61 Crop

Rainfall: 1.1.60 to 31.12.60 (inches)	41.26
Acreage in production (acres)	14.60
Clean coffee (tons)	3.81
Mbuni (lb.)	2,165

A total of 8,534 lb. of clean coffee and 1,671 lb. of seed were produced from the bearing acreage, on which the average yield was 6.65 cwt. per acre. The year's rainfall was some four inches below average. After good and abnormal rainfall in the first quarter, the remainder of the year was drier than normal.

Development:

The programme of re-organisation and development, which was started in 1959, was largely completed during 1960. Some minor improvements were installed in the coffee factory and a barbecue was added to the drying ground. Water was piped to the coffee plots and the water supply to the factory was improved. Permanent quarters were constructed to accommodate the labour force employed on the coffee area of the farm.

Koru Substation

A year of satisfactory progress and development can be recorded, in spite of changes in staff caused by Mr. Toomey's departure on leave in May and his subsequent resignation.

Much attention was devoted to consolidating the development made in the previous year; such work comprising couch eradication in established coffee, infilling gaps in the 1959 plantings and soil conservation operations. A total of 8.5 acres of coffee was planted in addition to infilling misses in the 1959 planting; some eight acres of Napier grass were established. In the existing paddocks some 30 acres were cleared of bush and the tree population was reduced.

Very little capital development in buildings and machinery was undertaken. A new hydraulic ram and main supply pipe were installed to bring water to staff quarters and homestead buildings. A capital development programme for the construction of farm buildings and staff quarters in permanent materials was started towards the end of the year.

It was possible to initiate the programme of field investigations with the first trials on Leaf Rust and establishment being laid down.

Kisii Substation

Progress in development and consolidation was satisfactory, most of the capital and field development being completed during the year.

A small coffee factory and water storage tank were built to process the station's crop; factory machinery, including an Aagaard pre-grader, were installed.

In the field only half an acre of coffee was planted, but the seedlings were stolen very soon afterwards. Older seedlings and infills in other trials were also stolen in June. Apart from these serious reverses, the rest of the field trial programme progressed satisfactorily. The officer in charge of the substation was again responsible for all coffee experiments in the district and the collection of K.7 seed from selected plots in the district.

Meru Substation

As in other districts East of the Rift, the year was notable for a prolonged dry period between the Long and Short Rains.

The station development was approaching completion by the end of the year. A fuel store and propagating frames were the only capital developments undertaken. During October coffee was planted on a bench-terraced plot of three acres, clones of new varieties were added to the seed garden and misses in other plots were infilled. The mulch grass area was extended, paddocks were cleared and planted with Rhodes grass or Nandi Setaria. As at Kisii, district trials were the responsibility of the officer in charge, who also organised seed collection for supplies required within the district.

Upper Kiambu Substation

As all the scheduled capital development works were completed in 1959 no improvements of this nature were needed during the year.

The field investigational programme was augmented to the stage where all the experiments planned were in operation and recorded for yield. The process of renewing the natural tree shade was taken a stage farther; ring-barking of old Grevillea trees was completed and replacements were planted on a uniform pattern throughout the trials.

The field trial area of the station consists of coffee which is fully matured and, prior to 1959, had been pruned on a single-stem system for many years. Early in 1959, conversion to multiple-stem was initiated by cutting up the primaries on one side of the tree to allow three strong suckers to develop on the open side. Conversion was completed during the year with the removal of the old stems. Four experiments were laid down on this area in 1959 to investigate the responses of shaded coffee to fertilizers, manure and mulch, to various systems of pruning and to methods of spraying with a copper fungicide to reduce seasonal leaf-fall.

Only small crops were recorded in 1959 and 1960, but the uniformity of the coffee was greatly improved during this period. No differences of statistical significance were evident between any of the treatments but, as the level of cropping rises, it is anticipated that variability will be further reduced. The mean yields recorded in 1960, in cwt. of clean coffee per acre, were as follows, with the coefficient of variation shown in parenthesis:

Copper Spray Trial	4.26 (30.3%)
Pruning Trial	2.85 (30.4%)
General Culture Trial	3.54 (19.2%)
Manurial Trial	4.02 (21.2%)

